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GENERAL

Mustang Field A-41
G. V. Ricks and J. M. David

Subsurface Storage of Liquid Hydrocarbons A-53
Neal E. Van Fossan

The Origin of Petroleum A-60
F. Morton

Drilling Practice Course Aids Petroleum Industry E-2
W. R. Mays

Features

Course of Oil A-4
Advertisers' Index A-6
With the Editors A-8
Highlights in Oildom A-10
Petrolic Personalities A-12
Meetings A-14
Letters to the Editors A-18
Petroleum Profile A-72
William Thomas Payne
General News E-6
General Personals E-13
Deaths E-17
The Petroleum Engineer's Continuous Tables E-19
(Installment No. 186)
Laugh With Barney E-34
Oil and Gas Trade News E-35
Trade Personals E-37
Books E-41
New Machinery and Supplies E-45
Trade Literature E-48

DRILLING AND PRODUCING

A Geologist Thinks About Deep Drilling B-5
G. Frederick Shepherd

Depth — The Third Dimension Frontier B-9
Ernestine Adams

Equipment, Materials, Tools for Cementing Deep Wells B-40
Phil Montgomery

Deepest Active Test in California Seeks Record B-47
William Rintoul

The Role of Mud in Deep Drilling B-51
Vernon B. Zacher and Bruce R. Zacher

Crooked Holes B-56
Arthur Lubinski

Drilling 75 Degree Dips in Canada B-58
Jack Menneer

Large Horsepower Pumps Save Rig Time B-64
Earle C. Hellums

Offshore Surveys Excite Oil Operators B-68
Richard Sneddon

What the Service Company Contributes to Deep Drilling B-75
W. C. "Hut" Erwin

Mud Is Important Factor in Deep Drilling B-78
G. O. Worley

Better Slush Pump Performance Is Possible B-81
Kenneth N. Mills

Does Deep Production Pay? B-91
William T. Rintoul

Deep Well Hydrafracing B-94

Features

Editorial B-3
Producing News B-94
What's Doing in Drilling B-96
Exploration Activities B-100
Running Tour With Men in the Industry B-104

REFINING AND GAS PROCESSING

Recent Trends and Developments in the Natural Gasoline Industry C-3
John F. Lynch

Major Natural Gas Conservation Project C-5
Bert J. Thompson

Mothballing a Gas Plant C-14
Richard Sneddon

New Subzero Tool Oil Developed C-18
Harry Chapin Plummer

Gasoline Plant Design C-20
Part 9
O. L. Lewis

Changes and Expansion Boost Yields C-28
Arch L. Foster

Isomerization of Olefins C-32
Lloyd Berg, H. A. Saner, L. D. Gustafson, W. J. Luke, W. S. Reveal

Plant Aids C-34
Hand Pipe Cleaner
Cooling Tower Cleaning Aid

Trends in Refinery Instrumentation C-37
Part 6
Charles F. Johnson, Jr.

Economics of the Air-Cooled Heat Exchanger C-42
J. C. Chase and H. E. Degler

Analytical Methods C-49
Determination of Sulfur in the Presence of Halogens

Features

Refining and Gas Processing News C-50
Refining and Gas Processing Personals C-53

OIL AND GAS PIPELINING

Canada's Longest Products System D-3
Leslie O. Rowland

Pipe Line Outlook D-12
Industry's Leaders Give Views for 1953

Electric Power for Gas System Operation D-20

Well Over the Billion Mark! D-26
Frank H. Love

Crude Oil Working Tanks D-32
R. M. Carter

Features

Oil and Gas Pipelining News D-40
Pipe Line Personals D-44
Pipe Line Projects D-46
With the Pipe Line Contractors D-49

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XUM

the course of OIL

A Message for 1953*

WE HAVE READ all the post-mortems about Eisenhower's election, but it seems to us that the most important reason for his victory has been mostly overlooked. If you will look back with us for a moment, we think you'll agree that at its inception the New Deal had a strong appeal to the conscience of men who wanted a better world — for others as well as for themselves. Perhaps you could see flaws in the philosophy and methods but the concept was certainly in tune with that trait of our national character that causes everyone to favor the underdog.

The Democratic party was defeated at the polls when, and only when, the spiritual appeal was lost and the campaign was pitched on a materialistic theme, "Don't let 'em take it away — you never had it so good." Of course, there were many other factors involved, but we think that talking about the bank balance to a family with a son in Korea was a poor approach.

This is all remarkably clear proof that Americans have not yet lost their desire for a more wholesome, more spiritual solution to their personal and national problems. Even in the great strongholds of labor, people refused to vote in what they were entitled to feel was their own best, though selfish, interest.

There is a lesson in all this — a lesson and a warning to business and industry. The president of a large oil company said it well the other day. His words were, "Business is getting another chance at its old-time leadership — probably its last chance. Our responsibility to our employees and to the public must be foremost in our minds. We must be sure that they get a fair break at all times. If we don't we could soon see the end of our economic system."

Yes, a free society requires that free men act with self-restraint, refraining from taking advantage of those who are less fortunate. Business men must become more sensitive to the legitimate aspirations of workmen; industry leaders must recognize the essentially spiritual nature of our millions of God-fearing Christian people.

Let us all work together and pray together in this coming year with faith in God, who through His Son gave us His promise of everlasting Peace.

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*This greeting, sent out by Big Chief Drilling Company, is a better expression of the hope and strength of the New Year than any we have seen.

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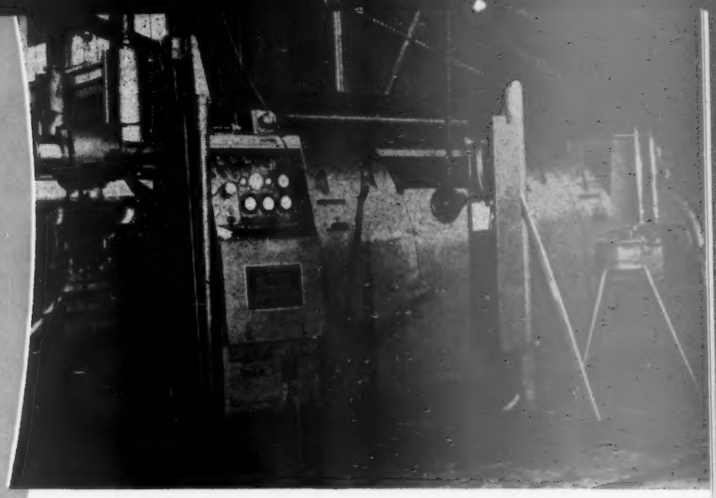

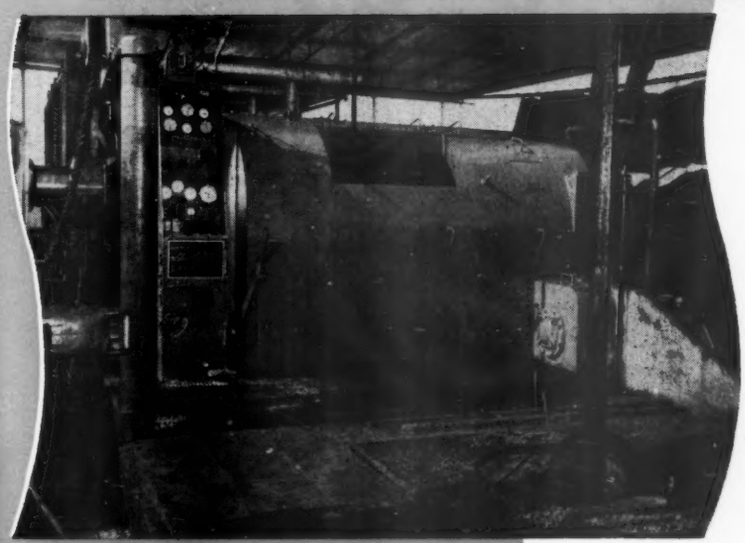

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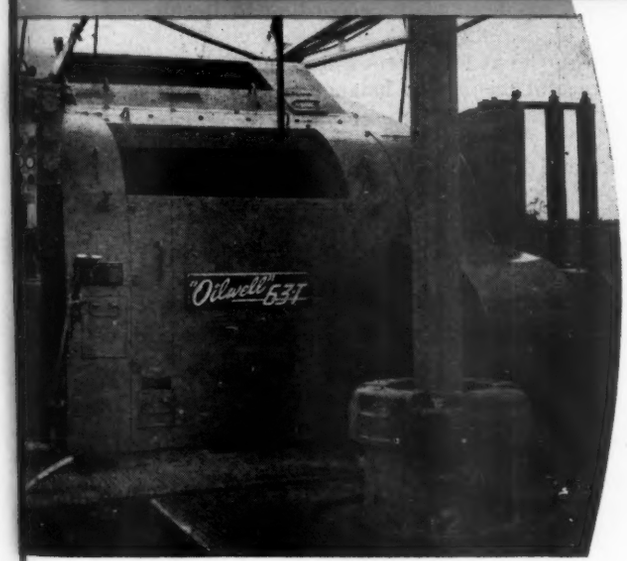

The No. 76

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This compact rig with its unitized assemblies and simplified air controls provides economical drilling to 10,000 feet with 4½" drill pipe; exceeding the range of most competitive models of comparable size and weight. Compound drive can be furnished with two or three engines and take-offs for either one or two pumps. Companion "Oilwell" equipment—No. 360 Crown Blocks, No. 300 Traveling Blocks, No. S5-200 Swivels, 20½" Rotaries and No. 214-P or No. 218-P Pumps.

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With the EDITORS.....

Proof of Oil's Origin

Strong and logical indications that petroleum is derived from living matter, vegetable, and/or animal, is shown by recent findings of Bureau of Mines and collaborating chemists, of the occurrence of metal-porphyrin combinations in crude oil. From certain California crudes H. N. Dunning and J. W. Moore of the Bureau's Bartlesville station, and M. O. Denekas of the University of Tulsa have identified chemical compounds composed of vanadium combined with porphyrin, while greater amounts of a nickel-porphyrin organo-metallic material have been determined. Porphyrin is a chemical "blood relative" of chlorophyll, the green coloring matter in plants and recently in dentrifices, and of hemoglobin from animal blood. In hemoglobin iron is associated with complex organic derivatives of pyrolle along with or including nitrogen, oxygen, carbon, hydrogen, etc. In chlorophyll the iron is absent but with magnesium present instead. Porphyrin is free of either metal, according to chemical textbooks, possibly a decomposition product.

Of greater immediate importance to the oil industry is the indication that these complexes may hinder secondary oil recovery, and are believed to delay or interfere with the displacement of oil in formations by flooding water. In refining, these minute quantities of metals may serve as poisons for catalysts, employed more and more in improving product qualities and properties.

Research thus reported to the American Chemical Society at Little Rock, Arkansas, have shown that the metal-porphyrin complexes are major contributors to the interfacial activity properties of petroleums. Interfacial activity and film-forming tendencies shown by some crude oils cannot be explained by the presence of 'impurities' containing oxygen, nitrogen or sulfur, and these researchers believe the discrepancy is traceable to the presence of these metal combinations. Formation of stable oil-field emulsions may be traceable to such materials present in minute amounts. These materials are being studied and a knowledge of their properties may enable the industry to improve oil recovery methods, and removal methods may aid the use of catalysts in refining.—A.L.F.

Middle East-Europe Pipe Line

The proposed 2500-mile gas pipe line from Middle East producing areas to European consuming centers would do a number of things for the rehabilitation of that continent. A greatly increased supply of fuel, at a lower cost, is needed to reestablish and expand its diversified economy. An abundant supply of low-cost fuel would thus raise the standard of living by increasing the number of jobs, reducing production costs, and supplying a source of heat not now available to the average citizen.

These accomplishments are well within the realm of possibility according to a study made by Bechtel International and published in this journal and others.

The pipe line, as proposed, would extend from the Kirkuk field in Iraq across Turkey, under the Bosporus between Asia and Europe near Istanbul, then proceed through northern Greece to Yugoslavia and Trieste. From there it would traverse northern Italy, cross the Alps to Austria, southern Germany, and on to Paris. Lateral lines totaling some 300 miles would connect industrial centers of Europe with the trunkline. The system's capacity initially would be 500,000,000 cu ft a day, and ultimately twice this.

It is estimated that the delivered cost of gas through such a system would be from 25 to 32 cents per 1000 cu ft. Represented in British thermal units this is a cost of from 30 to 50 cents per million Btus. The cost of solid fuels in leading European centers is in excess of 65 cents per million Btus under favorable industrial conditions and much higher for domestic use. The cost of manufactured gas in Paris is in excess of $1 per 1000 cu ft, the report shows.

Regarding the potential market, it is pointed out that the total average supply of both manufactured and natural gas in Europe was only 5 cu ft per day per person in 1949 as contrasted with 77 cu ft per day per person in the United States during the same period. When it is considered that there were approximately 150,000,000 persons in the United States at that time compared with an European population of some 330,000,000, the market possibilities are apparent.

The report has been made, according to Bechtel International, in response to requests from "those who see the far-reaching potentialities of this modern peaceful means for balancing some of the world's resources and promoting the general welfare."

The proposal has been forwarded by the Mutual Security Agency in Washington, D. C., to the Petroleum Committee, Office of European Economic Cooperation, in Paris. The latter agency is engaged in a long-term energy study. Although no decision is expected from the committee for some time, its ultimate reaction will be awaited with interest because of the several important factors enumerated.—F.H.L.

Alcohols and Ethylenes

Two recent announcements hold more than passing interest for the petrochemical industry, already victim of growing pains. Availability of huge quantities of "distress" Cuban blackstrap molasses, progenitor of fermentation alcohol, has induced at least one alcohol producer, Publicker Industries, to purchase a very large but undisclosed amount of this high sugar-content waste product for fermentation to ethyl alcohol. Strong threats to the stability of the alcohol market have been made by synthetic alcohol producers, alky made from olefinic gases. Publicker just acquired a big fermentation plant in Louisiana, closer to Cuba, an easy water haul. Price of alcohol has been dropping this year, still more synthetic capacity coming on; Publicker has thrown down the gage of battle. Looks good for alcohol consumers—industrial variety of course.—A.L.F.

Oil powers its progress . . . your bank helps you produce it!

Oil lies buried under one . . . two . . . three miles of dirt and rock. Finding it — recovering it — is a job for men of courage and skill — oilmen — with the will to work and the right to profit.

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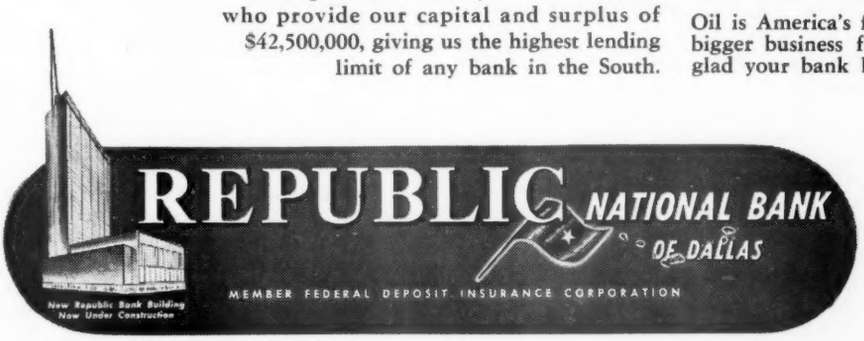
Years ago the Republic pioneered the first oil production loans by commercial banks. Since then our bank has made so many oil loans — in every oil-producing state in the nation — that oil men call us "The Oil Bank."

We like that name. It tells the story of Republic's leadership in working for this dynamic industry. It tells, too, of the many ways our bank works for *you* — for every oilman!

Oil is America's fortune. It means better living — bigger business for every American. We're glad your bank has a hand in it.

Fred B. Kearney
PRESIDENT



Capital and Surplus $42,500,000 — Largest in the South

HIGHLIGHTS IN OILDOM

Anderson Gets Cabinet Post

A former president of the Texas Mid-Continent Oil and Gas Association has been named Secretary of the Navy by President-elect Eisenhower. He is R. B. Anderson, general manager of the W. T. Waggoner Estate in Vernon, Texas. A graduate of the University of Texas, Anderson was president of Texas Mid-Continent for four years, and at present is a director of the General Mid-Continent Gas and Oil Association, American Petroleum Institute, Southwestern Bell Telephone, and Texas and Southwestern Cattle Raisers Association. He has taken a leave of absence from the Waggoner estate, which has various oil refining and producing holdings, to fulfill his duties as Secretary of the Navy.

Oil Industry Shown Competitive

The Oil Industry Information Committee has announced that a three-year study has revealed the existence of more than 200,000 oil businesses in the United States. An actual count, according to the committee, shows there are 44,602 businesses engaged in production, refining, transportation, and wholesale distribution of petroleum and petroleum products. The study further reports there are 188,253 service stations, of which 177,923 are single-unit establishments, and are classified as separate businesses. The committee noted that 95 per cent of these service stations are independently owned or operated by local business men.

Detergents Lower Tallow Sales

Soap makers are bemoaning the fact that the growing popularity of synthetic detergents has cut tallow sales by almost a third in the last four years. This was revealed at the National Renderers Association convention in San Francisco, California. Tallow prices have fallen from a high of 27 cents a pound in 1947 to a pre-Korea low of 5 cents. Detergents have been lowering the demand for tallow, while the greater use of meat by the average American family has led to an increased supply of tallow.

Oil Believed to Be Forming Now

The theory that petroleum is constantly being created was advanced recently in a report to the American Association for the Advancement of Science in Washington, D. C., by Dr. Paul V. Smith, Standard Oil Development Company. Smith reported that a variety of hydrocarbons, of which petroleum is a combination, were found in relatively recent sediments on the floor of the Gulf of Mexico. The origin of petroleum, though debatable, has been believed to be derived from the remains of living things, probably animals, but it was held that all petroleum existing in the world today was produced in the very distant past, probably from the abundance of microorganisms in the seas several hundred million years ago.

Dr. Smith stated that it might be that the petroleum-like mixture being formed in this present era is a composite of the hydrocarbon remains of many forms of marine life. "Crude oils of varying composition might result from changes in the relative contributions of different forms of marine life," he added.

Oil Recovery Projects Slowed

Water shortage, which has been an important question to the drought-stricken southwest, is having its affect on the oil industry, also. Frank W. Jessen, University of Texas petroleum engineer, told a water conference recently that insufficient water is hampering the industry's attempt to recover 15,000,000 bbl of Texas oil by secondary methods. Ten to 20 bbl of water are needed for each barrel of oil recovered through water flooding, Jessen declared, and added it would take a great quantity of water to help produce the 15 billion barrels of oil awaiting such assistance in Texas fields.

In some parts of the country water injection helps dispose of brine prduced with oil, but in others salt water is piped from fields where it is not needed to those where it will help, but that is not the case in most areas, Jessen, noted.

New Wells Under 1952 Goal

The oil industry exceeded the Petroleum Administration for Defense's aim for new wells at the mid-year, 1952, but is falling short of its goal of 50,000 new wells for the entire year. Up to November 22, the industry had drilled 41,379 wells, but it was predicted that the end result would be about 46,000. Reasons for the probable shortage of wells are debatable. Some members of the industry believe the steel strike and its resulting shortage is the primary cause, and others believe the failure of the industry to obtain a rise in oil prices while drilling costs have continued to go up has been the main reason. PAD program calls for the drilling of 55,000 new wells in 1953.

New Iranian Plan in Offing

It has been reported that the State Department has intimated American oil companies may buy Iranian oil, but warned the firms might face legal action from the British. Most American oil companies, however, are not interested in taking oil from Iran without approval of Britain. If the companies should help Iran take over this oil property, it is feared that they might encourage other countries to do the same thing Iran has.

In Washington recently, Max Ball, consultant, reported that in all but six of the oil-producing countries American companies face changes in oil contracts.

U. S. Secretary of State Acheson and British Foreign Minister Anthony Eden met in Paris recently to discuss the American plan for settling the Iranian oil questions. The U. S. compromise suggested payment of Anglo-Iranian Oil Company's demand for compensation of its nationalized holdings in Iran through an international third party. Restoration of Iran's oil industry by an international group, which would be entitled to market her output, was also suggested.

Antitrust Laws May Get Review

The seven major oil companies now under fire from the Justice Department for anti-trust activities, may be helped in a recommendation recently handed Secretary of Commerce Charles Sawyer. Business advisers have told Sawyer that interpretation and administration of antitrust law policy is confusing. The Business Advisory Council said there should be established in the Justice Department a conference section where business men could get authoritative antitrust opinions. In addition that review boards made up of businessmen, engineers, economists, and independent lawyers might be established to advise the Attorney General and the Fderal Trade Commission on whether to start anti-trust prosecutions.

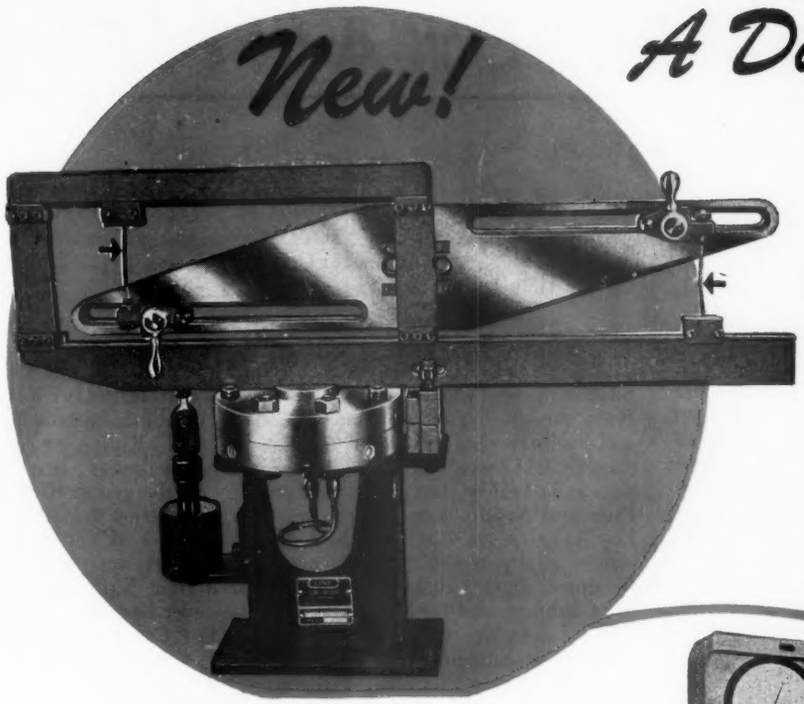
Texas Oil Activity Down

Texas oil and gas drilling activity fell short of its 1951 activities, the Texas Railroad Commission has reported. As of December 20, the state had reported 577 new oil fields compared to 520 last year. Operators reported 43 gas discoveries for the year, compared to 118 for the same period last year. Also reported were 10,070 oil wells completed, down 362 from 1951, and 736 completed gas wells, off 125.

Oil Demand Up in 1952

The American Petroleum Institute has reported domestic demand for oil in 1952 was about 2.6 billion barrels and total demand — including exports — exceed 2.8 billion, an increase of slightly more than 3 per cent from the last year. Frank M. Porter, API president, termed the 1952 increase "modest" compared with the larger percentage gains of recent years, but noted that was the 19th straight year of records in production, processing, and distribution of petroleum.

Porter reported that more crude oil, natural gas liquids, natural gas, motor fuel, and distillate fuel oil were produced in 1952 than in any previous 12-month period. Refinery capacity and the amount of crude oil processed reached new highs and a record number of wells were drilled, despite the strike in May, which tied up much of the industry.



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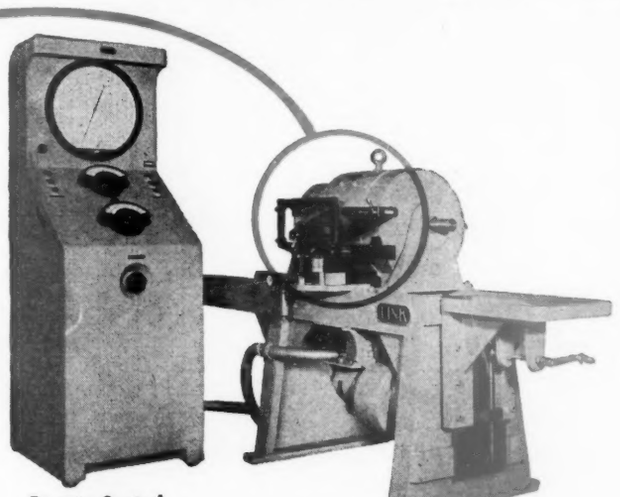

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PETROLIC PERSONALITIES

DICK SNEDDON

Whingding Season at Apogee

The California Chirstmas whingding season is just at its apogee as we write and we are already barely able to totter from one seance to the next. It all began on December 3 with a 750-man convocation of Petroleum Production Pioneers at the Rodger Young Auditorium, during which Cy Rubel, president of the organization, and a noted dispenser of serrated symphony, conducted what will probably prove to be the shortest annual meeting in annual meeting history. (It is rumored that Robert Ripley has his scouts checking up on this at the moment.) Admiral Hudson Drake, the Belridge purchasing chap, not the one who scuttled the Spanish armada, did his usual bang-up job of ladeling out the tittering waters and conditioning the assembly for the reminiscent blitz that was to follow.

The capable aides in this interesting project were such distinguished jigger manipulators as Bill Bates, the modest Shell Company drilling chief; Frank "Dutch" Lortscher, Signal Oil and Gas Company purchasing biggie and the travelingest individual since the passing of Marco Polo; Jack Freeman, a nice mannered and goodlooking Bethlehem Supply representative; Lee Laird, the Baash-Ross Caledonian, former Nomad prexy and a popular lad around the petrolic circuit; Ed Pellegrin, the big game fisherman from Macco Corporation; Glen Pitts, the affable Republic Supply chap; Joe Bergeron of Jet Lube, Inc., a descendant of old Gaul who speaks French like a native — a native of Watts; Don Pinnell, the Union Pacific Railway smoothie, who would make a sharp candidate for the Calvert series; Rudy Schweitzer, a tall, pleasant lad from Southwest Exploration Company; Bill Chonette, the Texas Company fly fisherman; Elmer Wycoff, the noted domino whiz from National Tube Company; Dave Carnahan, Emsco sales chief and flying fish angler of distinction; Chuck Ball, the amiable front end of Ball and Black; and Bill Tetsch, the Terminal Oil Company executive, one of the petroleum industry's ten best dressed men.

Behind the Scenes

The chief arranger of the PPP affair was Charlie Reichert, the National Supply Company ambassador, and one of the best arrangers in the business, who is also, incidentally, Grand Potentate of Al Malikah, which sounds terrific. Assisting Charlie in the various phases of the total enterprise were that famed Long Beach yachtsman, W. O. "Andy" Anderson of the Oil Tool Corporation; Ken Faulkner, a wildcat thespian of high caliber; Jim Hughes, of Lane Wells Company, 1953 presidential nominee of the Los Angeles chapter Nomads; the former Paraguayan, Tal Ledbetter of Union Oil Company; and H. J. "Ed" Stroud of Signal Oil and Gas Company, probably the most youthful pioneer in the western oil industry. Ed has already been close to 26 years with Signal and we'll wager that a hundred independent guesses at his age wouldn't average more than thirty which means that he must have begun to work at four!

Celebrities Ad Infinitum

Among the celebrities glimpsed at this elevated whingding were Julius Lehman, retired Standard Oiler who now devotes his time to singing "The Old Apple Tree," and his brother Jake, retired oilfield boiler maker from Maricopa who now devotes most of his time to trying to stop Julius from singing "The Old Apple Tree"; Ed Stearns, vice president of Universal Consolidated Oil Company, whose vim and energy are a lesson to all young oil people to live the clean and simple life—he is only surpassed as a big game hunter by Frank Buck. Also present were John Augsburger, former great from McCrate, if we may indulge our poetic yen, and now a substantial attache of the Kobe Corporation at Long Beach; A. E. "Enrique" Fowks, retired Union Oil Company executive, and famous also as the father of Al and Ernie who themselves are pioneers; Ralph Putman, another well known Union Oiler, formerly superintendent up in the Orcutt-Santa Maria area; Al Tietze, former Standard Oil superintendent from the San Joaquin Valley, widely known and highly regarded among Pacific Coast oil men; Elmer Bolton, the virtual mayor of El Segundo and erstwhile Ohio Oil Company great; Frosty Martin, the perennial chairman of the Long Beach Harbor Commission, and Frank Dinger, the old time Union Tool engineer

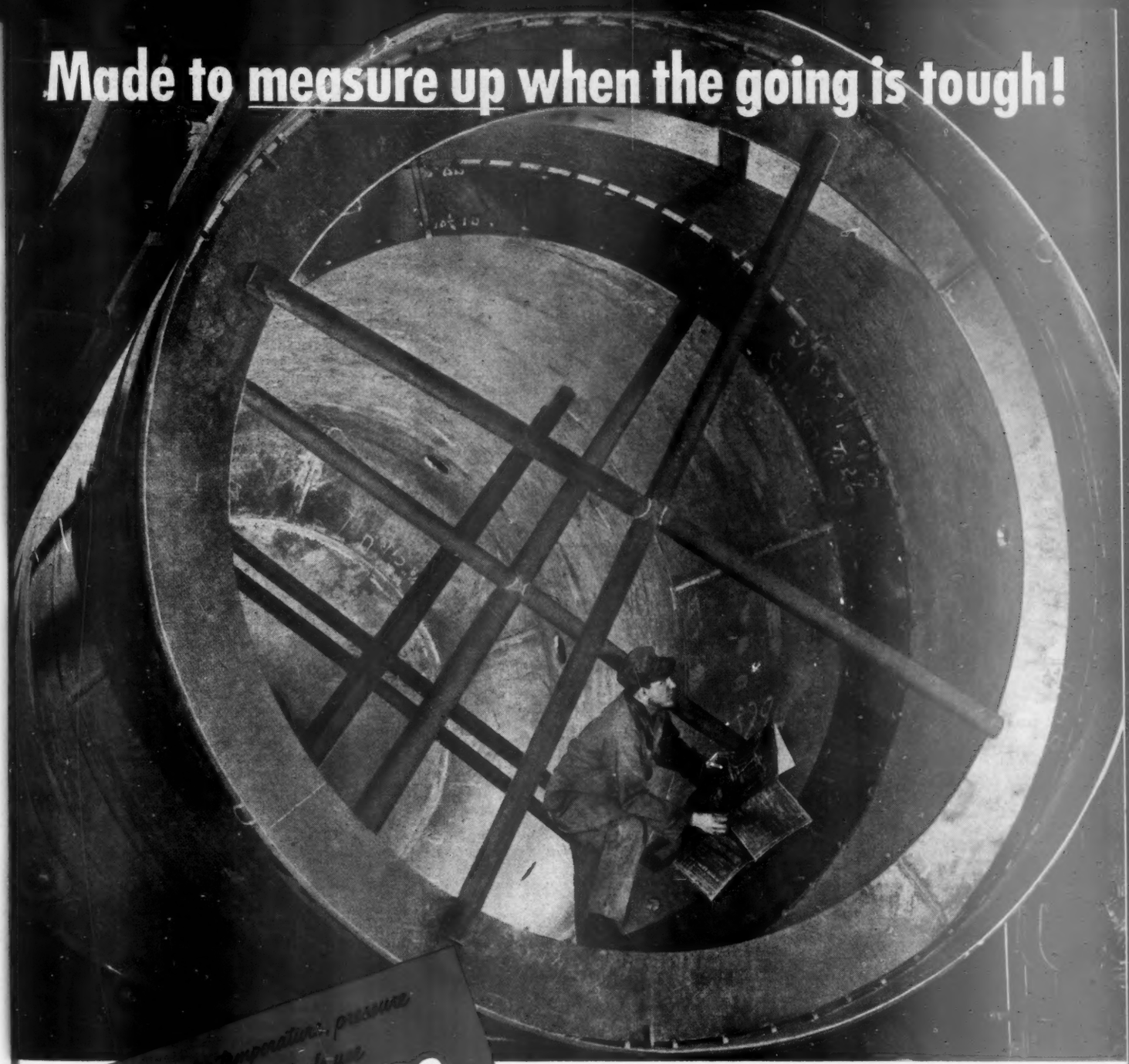
There's Just Too Much to Tell

Others much in evidence were R. E. "Daddy" Kline, Oil Well Supply pioneer who recently celebrated his 89th birthday; Hans Ross, the singing half of the Baash-Ross combination who began his career as an oilfield blacksmith; F. C. Ripley, Sr., retired CCMO executive, partially at least in whose honor a marker was set in Fellows last summer; Tom Hickey, the genial Hickey Pipe and Supply Company prexy who came from Ireland to Los Angeles via Coaling; Neil Norris, pioneer drilling contractor, and patron of the sport of kings, formerly with Loffland Brothers; Dave Faulkner, recently retired from National Supply Company and busier now than he has ever been in his life.

Lin Little, the well known Standard Oil Company retired field superintendent who was first honorary president of Petroleum Production Pioneers; Ted Sutter, vice president of Baker Oil Tools, Inc., recent recipient of his thirty year pin; Ham Bell, drilling contractor, artist, popular Petroleum Clubber, and man about town; Bill Sutherlin, another retired Standard Oiler well known and much admired in these parts; C. S. "Pen" Penfield, retired Shell drilling superintendent, now a rancher of substance; and simply scads of other notables that lack of time and space preclude our mentioning.

We had hoped to tell something of the Wildcat play, the Desk & Derrick Club party, the Pittsburg Steel Company open house, and that amazing evening of good fellowship and gastronomic delight presented annually by Emsco Derrick and Equipment Company and Youngstown Steel Products Company of California. They were all wonderful but discussion will have to be postponed until the next issue. Meantime, Happy New Year to all who have followed the reading thus far!

Made to measure up when the going is tough!



To meet temperature, pressure and chemicals use

M. W. KELLOGG

process equipment

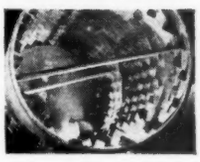
Large and small vessels for handling unusual corrosives . . . extremes in high and low temperature operations . . . high vacuum to high pressure—these are the vessels that refiners time after time "earmark" for Kellogg, because Kellogg-fabricated vessels measure up when the going is tough.

- Pressure Vessels
- Vacuum Vessels
- Fractionating Columns
- Drums and Shells
- Heat Exchangers
- Process Piping
- Hi-pressure—Hi-temp Power Piping
- Bends and Headers
- Forged and Welded Fittings
- Radial Brick Chimneys
- Concrete Chimneys

Continuing Study of behavior of metals under stress at high temperatures has produced valuable design data.

Shop Layout Craftsmen are fully experienced in vessel fabrication from nozzle positioning to "knockdown" fabrication for field assembly.

Extensive Facilities from bending of plate to final machining of precision surfaces permit complete fabrication under the same roof.



Special Welding Techniques and stress relieving methods assure equipment performance even under severest operating conditions.

Rigid Quality Control, devised by specialists, including chemical and micro analyses as well as mechanical and non-destructive testing.

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The Canadian Kellogg Company Ltd. has established complete shop facilities for the fabrication of all types of piping at EDMONTON, Alberta. Inquire directly or through any Kellogg or Canadian Kellogg office.

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Look for the wrench with that guarantee label to make sure you get the extra-easy work and extra durability that have made RIDGID the world's most popular wrench.

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Save work and money—buy genuine RIDGIDs at your Supply House.

THE RIDGE TOOL COMPANY, ELYRIA, OHIO, U.S.A.

RIDGID

Work-Saver Pipe Tools

Meetings

Jan. 8-9—**Midwest Research Institute,** symposium on industrial applications of automatic computing equipment, Hotel President, Kansas City, Missouri.

Jan. 12-16—**Society of Automotive Engineers,** annual meeting and engineering display, Sheraton-Cadillac, Detroit, Michigan.

Jan. 19-20—**Independent Petroleum Association of America,** executive committee, quarterly meeting, The Campbell House, Lexington, Kentucky.

Jan. 19-21—**Pipe Line Contractors Association,** Shamrock Hotel, Houston, Texas.

Jan. 19-23—**American Institute of Electrical Engineers,** winter general meeting, Hotel Statler, New York, New York.

Jan. 21-23—**Society of Plastics Engineers,** Hotel Statler, Boston, Massachusetts.

Jan. 26-29—**Compressed Gas Association, Inc.,** annual convention, Waldorf-Astoria, New York, New York.

Feb. 1-6—**American Society for Testing Materials,** committee on petroleum products and lubricants, Hotel Cleveland, Cleveland, Ohio.

Feb. 2-6—**National Association of Corrosion Engineers,** corrosion short course, University of California at Berkeley.

Feb. 4-6—**Western Computer Conference,** Hotel Statler, Los Angeles, California.

Feb. 5-7—**Missouri Petroleum Association,** annual convention, Hotel President, Kansas City, Missouri.

Feb. 5-7—**Southwestern I.R.E. Conference and Electronics Show,** Plaza Hotel, San Antonio, Texas.

Feb. 12-13—**Western Petroleum Refiners Association,** regional meeting, Beaumont Hotel, Beaumont, Texas.

Feb. 16-21—**American Institute of Mining and Metallurgical Engineers,** annual meeting, Statler Hotel, Los Angeles, Calif. nia.

Feb. 18—**Instrument Society of America,** regional meeting, Hotel Statler, New York City, N. Y.

Feb. 25-26—**Wisconsin Petroleum Association,** Hotel Schroeder, Milwaukee, Wisconsin.

Feb. 27—**Natural Gasoline Association of America,** regional, Scarbauer Hotel, Midland, Texas.

March 2-6—**American Society for Testing Materials,** spring meeting, Statler Hotel, Detroit, Michigan.

March 4-6—**American Petroleum Institute,** Division of Production, Hilton Hotel, Fort Worth, Texas.

March 8-11—**American Institute of Chemical Engineers,** Bueno Vista Hotel, Biloxi, Mississippi.

March 9-12—**National Electrical Manufacturers Association,** Edgewater Beach Hotel, Chicago, Illinois.

March 15-17—**American Petroleum Institute,** Division of Production, Eastern district spring meeting, William Penn Hotel, Pittsburgh, Pennsylvania.

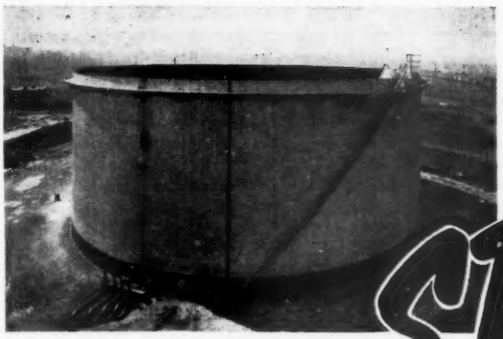
March 15-19—**American Institute of Mining and Metallurgical Engineers,** Statler Hotel, Los Angeles, California.

March 16-20—**National Association of Corrosion Engineers,** Hotel Sherman, Chicago, Illinois.

March 18-20—**American Petroleum Institute,** Division of Production, Mid-Continent district meeting, Mayor Hotel, Tulsa, Okla.

March 23-25—**Western Petroleum Refiners Association,** annual meeting, Plaza Hotel, San Antonio, Texas.

March 23-26—**American Association of Petroleum Geologists,** Society of Exploration Geophysicists, and Society of Economic Paleontologists, annual meeting, Rice and Shamrock Hotels, Houston, Texas.

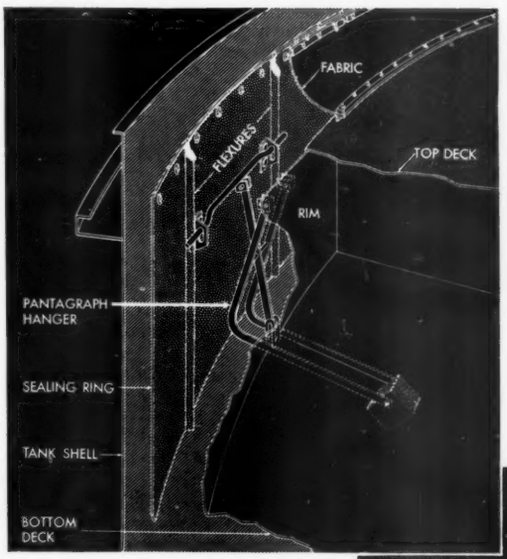


STOP EVAPORATION LOSSES From Floating Roof Tanks ...with the HORTON SEAL*

The deck of a floating roof covers a large percentage of the area of the tank. Double-Deck and Pontoon Floating Roofs also provide insulation over a portion or all of the liquid in the tank. The most important construction feature of a floating roof, however, is the seal that closes the space between the deck and the tank shell.

The real secret of Horton floating roof performance is the seal that so effectively closes the space between the deck of the roof and the shell of the tank. Three special features help insure its positive operation. They are: (1) The continuous sealing ring with vertical flexures every 22 inches of circumference that allow it to follow the contour of the tank shell. (2) The pantagraph hangers that hold the sealing ring against the tank shell and keep the roof centered at all times. (3) The gastight, weatherproof, flexible fabric that closes the space between the deck of the roof and the top of the sealing ring making the space in the seal vaportight.

The Horton Seal is standard construction on all Horton Floating Roofs. Write our nearest office for more complete details.



Above: Diagrammatic drawing of a pantagraph hanger showing how it applies a gentle outward pressure at all times on the sealing ring.

Right: View of pantagraph hangers and sealing ring being assembled on an actual roof.

Far Right: Looking down into rim space showing view of hangers and sealing ring in place before fabric was installed.

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Chicago 4.....2481 McCormick Bldg.
Cleveland 15.....2251 Midland Bldg.
Detroit 26.....1538 Lafayette Bldg.
Havana.....402 Abreu Bldg.
Houston 2.....2137 C & I Life Bldg.
Los Angeles 17...1546 General Petroleum Bldg.
New York 6.....3373—165 Broadway Bldg.
Philadelphia 3..1635—1700 Walnut Street Bldg.
San Francisco 4.....1564—200 Bush St.
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Sociedade Chibridge de Construcoes Ltda., Av. Franklin Roosevelt, 194-5-704-C, Rio de Janeiro, Brazil

March 23-27—**American Society of Metals,** Western Metal Congress and Exposition, Pan-Pacific Auditorium, Los Angeles, California.

March 28—**North Texas Oil and Gas Association,** annual meeting, Kemp Hotel, Wichita Falls, Texas.

March 30-31—**Texas Independent Producers and Royalty Owners Association,** annual meeting, San Antonio, Texas.

March 30-April 1—**Mid-West Gas Association,** Broadmoor Hotel, Colorado Springs, Colorado.

April 12-May 23—**Empire Mining and Metallurgical Congress,** Australasian Institute of Mining and Metallurgy, Australia.

April 13-15—**American Society of Lubrication Engineers,** annual meeting and exhibit, Hotel Statler, Boston, Massachusetts.

April 13-15—**Canadian Institute of Mining and Metallurgy,** annual meeting, The MacDonald, Edmonton, Alberta, Canada.

April 15-17—**American Petroleum Institute,** Division of Production, eastern district, William Penn Hotel, Pittsburgh, Pennsylvania.

April 15-17—**National Petroleum Association,** semi-annual meeting, Hotel Cleveland, Cleveland, Ohio.

April 20-22—**American Petroleum Institute,** Division of Transportation, products pipe line conference, Hotel Muehlebach, Kansas City, Missouri.

April 21-23—**Southwestern Gas Measurement Short Course,** University of Oklahoma, Norman.

April 24-25—**Interstate Oil Compact Commission,** 1953 spring meeting, Roosevelt Hotel, New Orleans, Louisiana.

April 26-29—**American Institute of Chemical Engineers,** joint meeting with Chemical Institute of Canada, Royal York Hotel, Toronto, Canada.

April 27-28—**Independent Petroleum Association of America,** mid-year meeting, Jefferson Hotel, St. Louis, Missouri.

April 29-May 1—**Natural Gasoline Association of America,** Rice Hotel, Houston, Texas.

May 4-6—**Liquefied Petroleum Gas Association,** annual convention, Conrad Hilton Hotel, Chicago, Illinois.

May 7-8—**American Petroleum Institute,** Division of Production, Rocky Mountain district, Gladstone Hotel, Casper, Wyoming.

May 10-12—**Pennsylvania Petroleum Association, Inc.,** Bedford Springs Hotel, Bedford Springs, Pennsylvania. (Tentative)

May 11-13—**Southern Gas Association,** Jung Hotel, New Orleans, Louisiana.

May 11-14—**American Petroleum Institute,** Division of Refining, Hotel Commodore, New York, New York.

May 11-15—**National Fire Protection Association,** annual meeting, Edgewater Beach Hotel, Chicago, Illinois.

May 14-23—**International Petroleum Exposition,** Tulsa, Oklahoma.

May 24-27—**American Gas Association,** production and chemical conference, Hotel New Yorker, New York City.

May 28-29—**Natural Gas and Petroleum Association of Canada,** London, Ontario, Canada.

June 2-3—**American Petroleum Institute,** Division of Production, Pacific Coast district, Statler Hotel, Los Angeles, California.

June 7-12—**Society of Automotive Engineers,** summer meeting, The Ambassador and Ritz-Carlton, Atlantic City, New Jersey.

June 15-19—**American Institute of Electrical Engineers,** general meeting, Chalfonte-Haddon Hotel, Atlantic City, New Jersey.

June 15-19—**American Petroleum Institute,** Division of Production, midyear committee conference, Hotel William Penn, Pittsburgh, Pennsylvania.

June 16-19—**American Welding Society,** national spring technical meeting, Shamrock Hotel, Houston, Texas.

June 16-24—**European Congress for Chemical Engineering,** Paris, France.

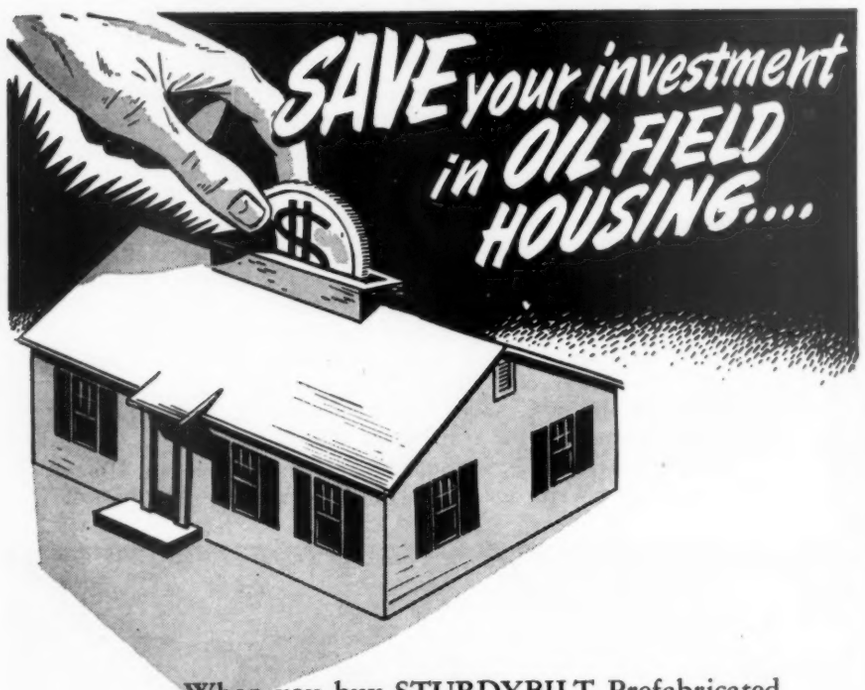
June 18-19—**Pennsylvania Grade Crude Oil Association,** annual meeting, Hotel William Penn, Pittsburgh, Pennsylvania.

June 21-25—**American Society for Testing Materials,** annual meeting, Chalfonte-Haddon, Atlantic City, New Jersey.

June 29-July 3—**American Society for Testing Materials,** annual meeting, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

July 16-23—**International Bar Association,** Palacio de Justicia, Madrid, Spain.

Aug. 31-Sept. 5—**International Association for Hydraulic Research,** Minneapolis, Minnesota.



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Check the advantages of STURDYBILT houses, garages, warehouses, tool houses and other buildings before you buy any oil field housing.

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NOMADS TO MEET

New York, N. Y., Chapter, First Monday of the Month, Louis Sherry's New York. Secretary, Jesse E. Hickman.

Houston Chapter, Second Monday of the Month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First Monday of the Month. Secretary M. W. Hiltpold.

EXCAVATION VOLUMES IN TRENCHES, ETC., CU. YD. PER 1000 LINEAL FT.

Depth of trench, in.	Width of trench, in.																					
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12	18.5	24.7	30.9	37.0	43.2	49.4	55.6	61.7	67.9	74.1	80.2	86.4	92.6	98.8	105.	111.	117.	123.	130.	136.	142.	148.
14	21.6	28.8	36.0	43.2	50.4	57.6	64.8	72.0	79.2	86.4	93.6	101.	108.	115.	122.	130.	137.	144.	151.	158.	166.	173.
16	24.7	32.9	41.2	49.4	57.6	65.8	74.1	82.3	90.5	98.8	107.	115.	123.	132.	140.	148.	156.	165.	173.	181.	189.	198.
18	27.8	37.0	46.3	55.6	64.8	74.1	83.3	92.6	102.	111.	120.	130.	139.	148.	157.	167.	176.	185.	194.	204.	213.	222.
20	30.9	41.1	51.4	61.7	72.0	82.3	92.6	103.	113.	123.	134.	144.	154.	165.	175.	185.	195.	206.	216.	226.	237.	247.
22	33.9	45.3	56.6	67.9	79.2	90.5	102.	113.	124.	136.	147.	158.	170.	181.	192.	204.	215.	226.	238.	249.	260.	272.
24	37.0	49.4	61.7	74.1	86.4	98.8	111.	123.	136.	148.	160.	173.	185.	198.	210.	222.	235.	247.	259.	272.	284.	296.
26	40.1	53.5	66.9	80.2	93.6	107.	120.	134.	147.	160.	174.	187.	201.	214.	227.	241.	254.	267.	281.	294.	308.	321.
28	43.2	57.6	72.0	86.4	101.	115.	130.	144.	158.	173.	187.	202.	216.	230.	245.	259.	274.	288.	302.	317.	331.	346.
30	46.3	61.7	77.2	92.6	108.	123.	139.	154.	170.	185.	201.	216.	231.	247.	262.	278.	293.	309.	324.	340.	355.	370.
32		65.8	82.3	98.8	115.	132.	148.	165.	181.	198.	214.	230.	247.	263.	280.	296.	313.	329.	346.	362.	379.	395.
34		69.9	87.4	105.	122.	140.	157.	175.	192.	210.	227.	245.	262.	280.	297.	315.	332.	350.	367.	385.	402.	420.
36		74.1	92.6	111.	130.	148.	167.	185.	204.	222.	241.	259.	278.	296.	315.	333.	352.	370.	389.	407.	426.	444.
38		78.2	97.7	117.	137.	156.	176.	195.	215.	235.	254.	274.	293.	313.	332.	352.	371.	391.	410.	430.	450.	469.
40		82.3	103.	123.	144.	165.	185.	206.	226.	247.	267.	288.	309.	329.	350.	370.	391.	412.	432.	453.	473.	494.
42			108.	130.	151.	173.	194.	216.	238.	259.	281.	302.	324.	346.	367.	389.	410.	432.	454.	475.	497.	519.
44			113.	136.	158.	181.	204.	226.	249.	272.	294.	317.	340.	362.	385.	407.	430.	453.	475.	498.	521.	543.
46			118.	142.	166.	189.	213.	237.	260.	284.	308.	331.	355.	379.	402.	426.	450.	473.	497.	521.	544.	568.
48			123.	148.	173.	198.	222.	247.	272.	296.	321.	346.	370.	395.	420.	444.	469.	494.	519.	543.	568.	593.
50			129.	154.	180.	206.	231.	257.	283.	309.	334.	360.	386.	412.	437.	463.	489.	514.	540.	566.	592.	617.
52				160.	187.	214.	241.	267.	294.	321.	348.	374.	401.	428.	455.	481.	508.	535.	562.	588.	615.	642.
54				167.	194.	222.	250.	278.	306.	333.	361.	389.	417.	444.	472.	500.	528.	556.	583.	611.	639.	667.
56				173.	202.	230.	259.	288.	317.	346.	374.	403.	432.	461.	490.	519.	547.	576.	605.	634.	663.	691.
58				179.	209.	239.	268.	298.	328.	358.	388.	418.	448.	477.	507.	537.	567.	597.	627.	656.	686.	716.
60				185.	216.	247.	278.	309.	339.	370.	401.	432.	463.	494.	525.	556.	586.	617.	648.	679.	710.	741.
62					223.	255.	287.	319.	351.	383.	415.	446.	478.	510.	542.	574.	606.	638.	670.	702.	734.	765.
64					230.	263.	296.	329.	362.	395.	428.	461.	494.	527.	560.	593.	626.	658.	691.	724.	757.	790.
66					238.	272.	306.	339.	373.	407.	441.	475.	509.	543.	577.	611.	645.	679.	713.	747.	781.	815.
68					245.	280.	315.	350.	385.	420.	455.	490.	525.	560.	595.	630.	665.	700.	735.	770.	805.	840.
70					252.	288.	324.	360.	396.	432.	468.	504.	540.	576.	612.	648.	684.	720.	756.	792.	828.	864.
72						296.	333.	370.	407.	444.	481.	519.	556.	593.	630.	667.	704.	741.	778.	815.	852.	889.
74						305.	343.	381.	419.	457.	495.	533.	571.	609.	647.	685.	723.	761.	799.	837.	876.	914.
76						313.	352.	391.	430.	469.	508.	547.	586.	626.	665.	704.	743.	782.	821.	860.	899.	938.
78						321.	361.	401.	441.	481.	522.	562.	602.	642.	682.	722.	762.	802.	843.	883.	923.	963.
80						329.	370.	411.	453.	494.	535.	576.	617.	658.	700.	741.	782.	823.	864.	905.	947.	988.
82							380.	422.	464.	506.	548.	591.	633.	675.	717.	759.	801.	844.	886.	928.	970.	1010.
84							389.	432.	475.	518.	562.	605.	648.	691.	735.	778.	821.	864.	907.	951.	994.	1040.
86							398.	442.	487.	531.	575.	619.	664.	708.	752.	796.	841.	885.	929.	973.	1020.	1060.
88							407.	453.	498.	543.	588.	634.	679.	724.	770.	815.	860.	905.	951.	996.	1040.	1090.

Earth and clay increase in bulk ¼ when dug, but subside 1/5 in height and decrease 1/6 in bulk when formed into embankments.
Sand and gravel increase in bulk 1/12 when dug; sand subsides in embankment ¼ in height; gravel from 1/10 to 1/12 according to coarseness. Rock increases ½ of its original bulk when excavated.

APPROXIMATE WEIGHT OF EARTHS, ROCKS, ETC., LB. PER CU. YD.

Sand	3000
Gravel	3000
Mud	2500
Marl	2600
Clay	3100
Chalk	3600
Sandstone	3900
Shale	4000
Quartz	4100
Granite	4200
Trap	4200
Slate	4300

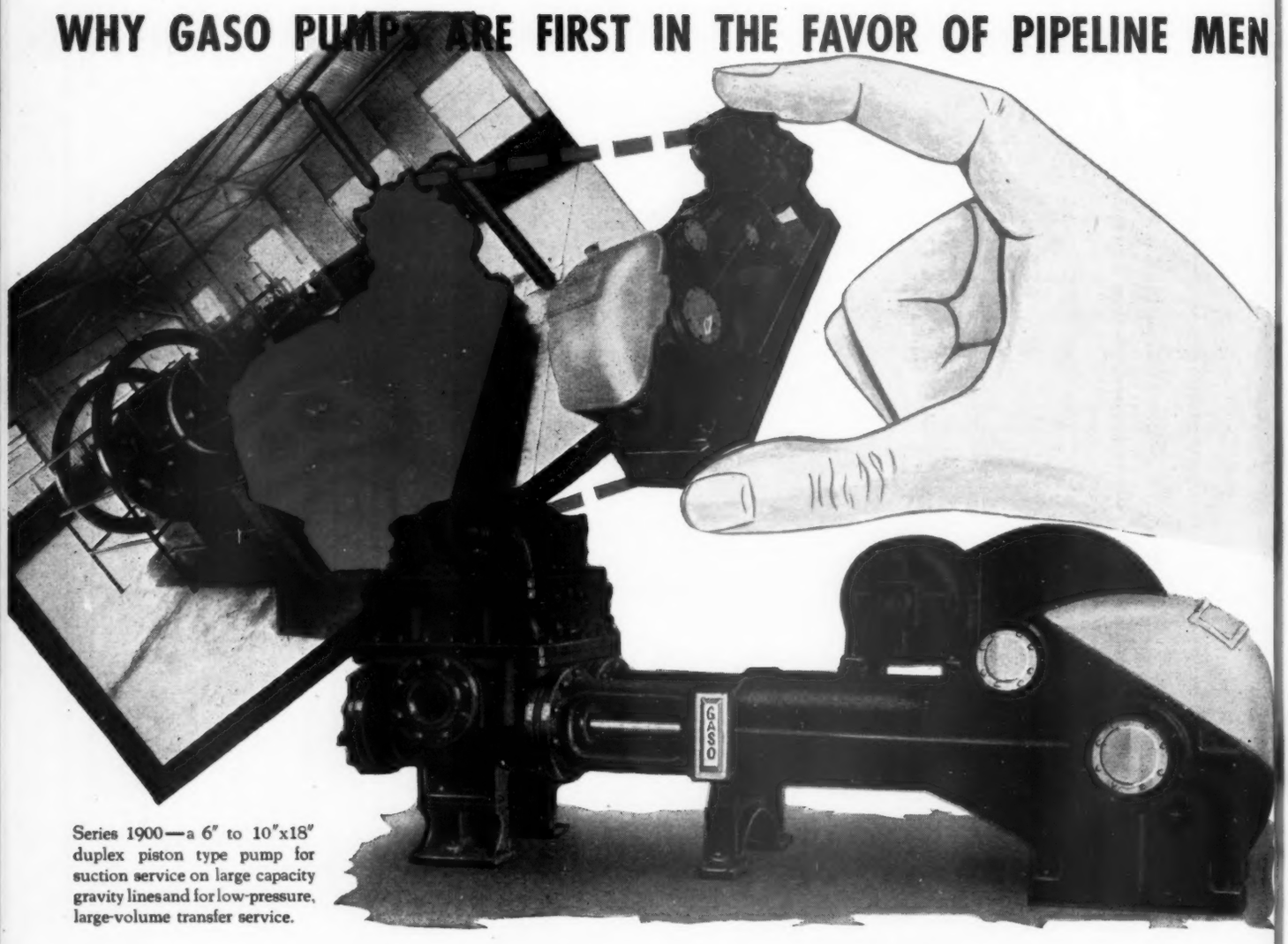
QUANTITIES OF EARTH EQUAL TO A TON (as filled into trucks)

	Volume cu. ft.	Volume cu. yd.
River sand	21	0.78
Pit sand	22	0.81
Coarse gravel	23	0.85
Marl	28	1.04
Stiff clay	28	1.04
Lump chalk	29	1.07
Earth	33	1.22

NATURAL SLOPES OF EARTH

	Avg. angle with horizontal
Gravel	40°
Dry sand	38°
Sand	22°
Vegetable earth	28°
Compact earth	50°
Shingle	39°
Rubble	45°
Clay, well drained	45°
Clay, wet	16°

WHY GASO PUMPS ARE FIRST IN THE FAVOR OF PIPELINE MEN



Series 1900—a 6" to 10"x18" duplex piston type pump for suction service on large capacity gravity lines and for low-pressure, large-volume transfer service.

They Fit The Job Precisely

It is never necessary to fit square pegs into round holes when you use Gaso Pumps. For every need in their field there is a size and model that fits the conditions as if tailor-made to the job. Do you have a copy of our latest catalog?

GASO PUMPS

XUM

72 WELLS PUMPING WITH . . .

ANOTHER *Electric Power* CASE HISTORY

Electric Power

Pictured is one of the 72 Electrified wells pumping in the Sharon Ridge Field, in Scurry County, Texas. This is proof positive that more and more oil companies are switching to Low Cost Purchased Electric Power for pumping. Investigate today, you'll find you can DO MORE, FOR LESS with Low Cost Purchased Electric Power. So, in '53 make it *PEP. Call the Power Engineer at your nearest Electric Power Company for facts.

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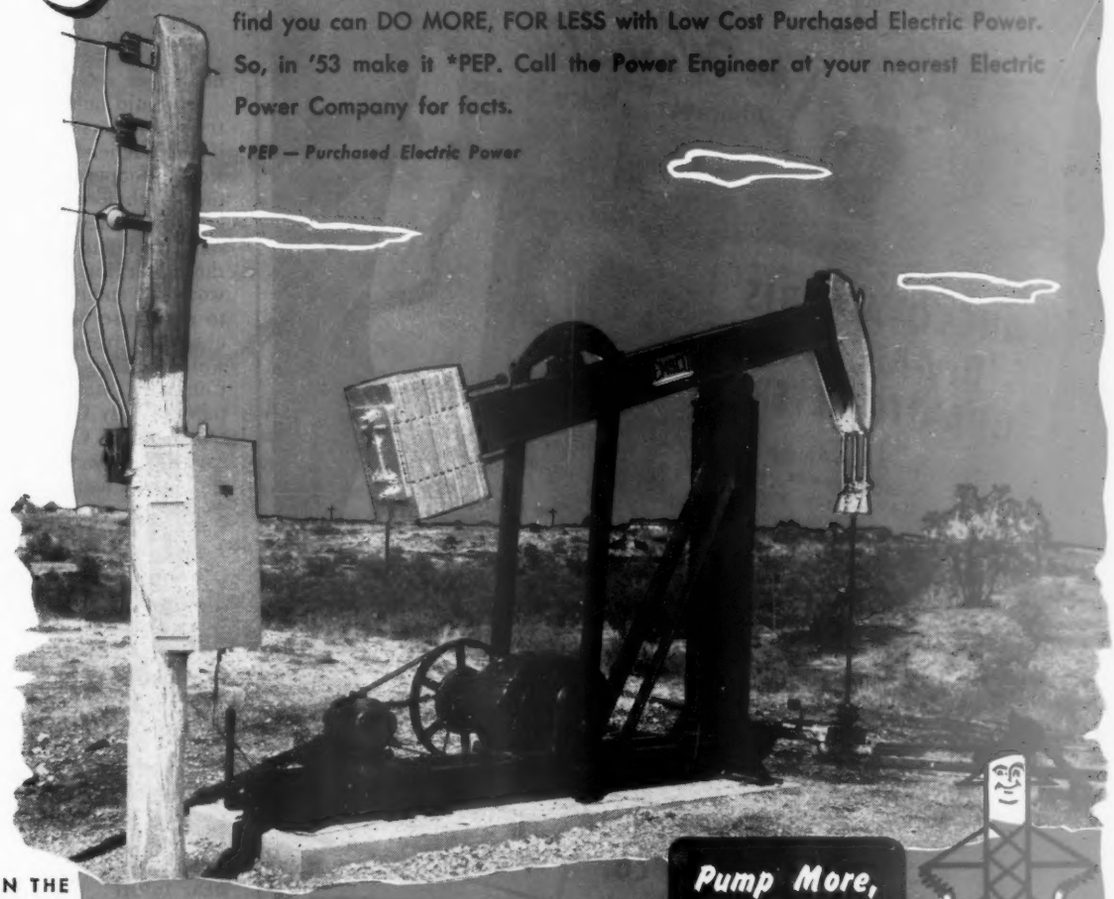

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LETTERS

Questions Formation

To The Petroleum Engineer:

This letter concerns Paul H. Umbach, consulting geologist and formerly with Stanolind Oil and Gas Company in Albuquerque, New Mexico. His report in the May issue of *The Petroleum Engineer*, Drilling and Producing Edition, showing map of the "Black Mesa Basin" in Northeast Arizona and stating that the Harkey et al's test well in Coconino County is bottomed in granite at 2265 ft and that the Colgrove test well in Apache County is also bottomed in granite at 2517 ft.

The above remark has confused many oil people interested in exploration and many remarks made concerning this report by Mr. Umbach.

After checking with reliable geologists, it was found that the Harkey et al's well is bottomed in the top of the Pennsylvanian and the Colgrove well is bottomed in the Supai formation.

I believe that his report is in error and should be corrected. I might add that this is serious and misleading to the oil industry.

J. E. Stuler

P.S. These test wells are not abandoned.

Stuler Map Company
Phoenix, Arizona

Umbach's Reply

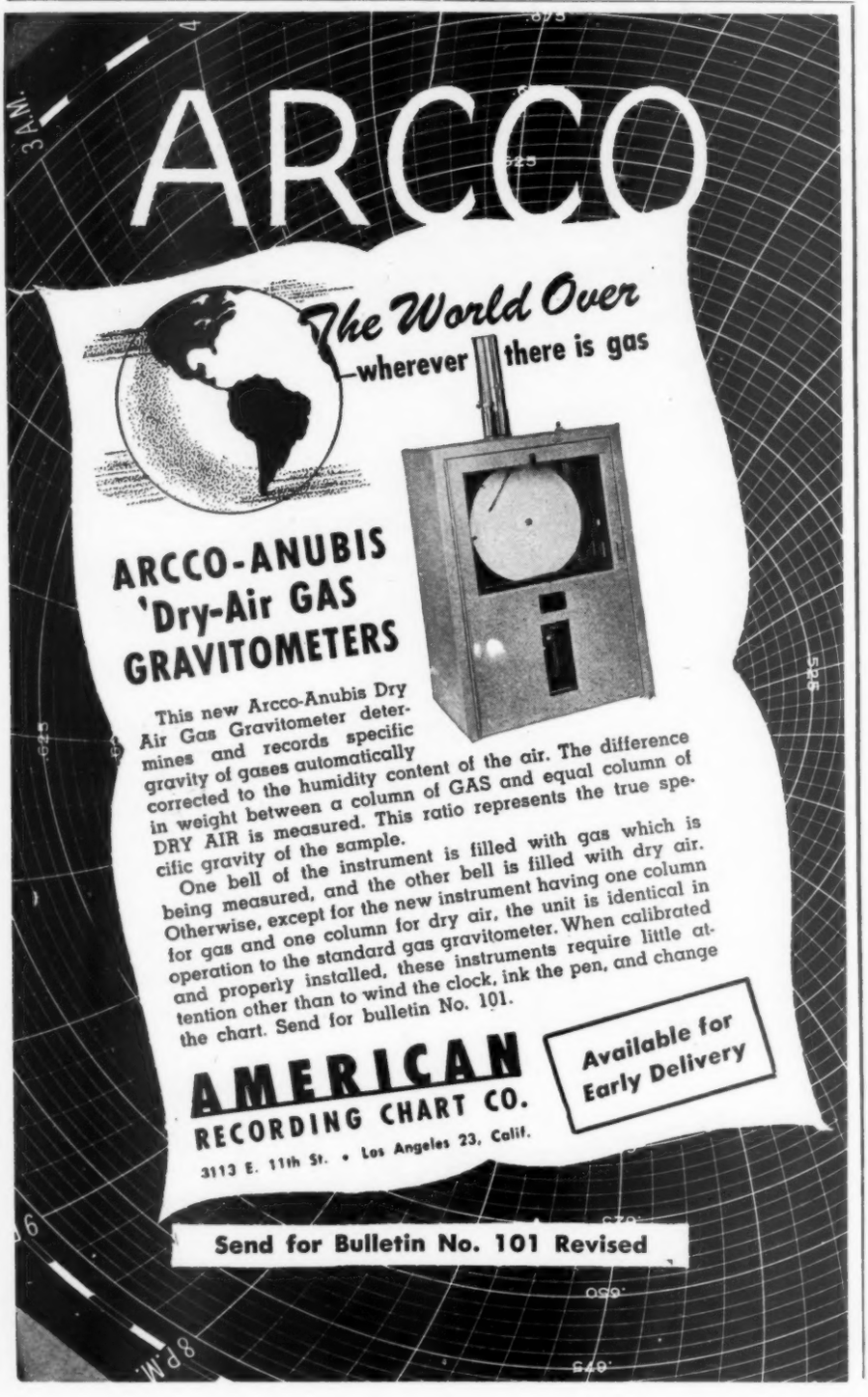
To The Petroleum Engineer:

I received a copy of the letter from Mr. Stuler in regard to a table in my article published in May 1952. We have always had considerable difficulty in obtaining accurate information on Arizona wells. The samples have not been made available and consequently the information reported was taken from scout information given out in the Four Corners Scout Check at Farmington, New Mexico. Since information on these wells was withheld from the scout check, the scouts were compelled to obtain information from what they thought was the best source available. On all of the other wildcat wells reported samples had been made available, and, of course, the formation penetrated had been checked. Since we did not have the samples to check the formation penetrated on the two wells in Arizona, it is entirely possible that the report on them may not have been correct.

It would be a great help to the industry, as well as to the Black Mesa Basin, if the independent operators in that area would cooperate in releasing information on their wells. It would not be necessary to release the information as the well is being drilled or immediately thereafter, but it is believed that 60 days would be sufficient time for the operator to make use of the information that he obtained from drilling the well. On wells drilled by Amerada Petroleum Company, Stanolind Oil and Gas Company, Skelly Oil Company and Sinclair Oil and Gas Company information and samples have been released while the wells were being drilled. If independent operators would release their information within at least 60 days after the completion of the well, it would correct any erroneous reports that might have been made. The determination of granite in the wells in Arizona has not been difficult and there is no reason for any controversy in regard to a well penetrating granite if samples have been made available to geologists working in the area.

I am sorry that this report was made in *The Petroleum Engineer* without further proof of the data. It is hoped that data in Arizona will become more available to the operators in the area in the near future.

In regard to the wells not being abandoned, this, of course, is a matter of terminology. The term "abandoned" in the oil industry does not necessarily mean that the well is permanently abandoned. Wells are carried as active as long as they actually are active and oftentimes several months after they become inactive. In order to avoid carrying a large volume of inactive wells on weekly reports companies often show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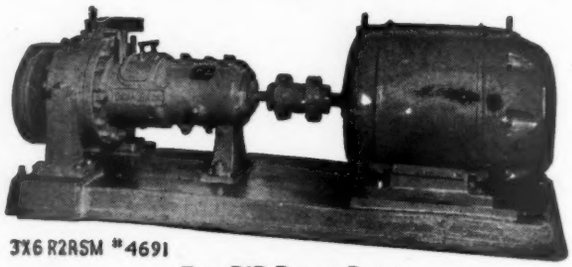
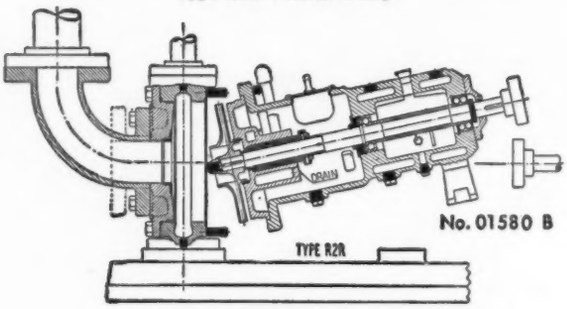


Type R2R Process Pump



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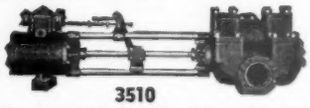

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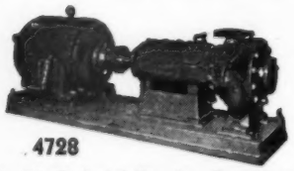

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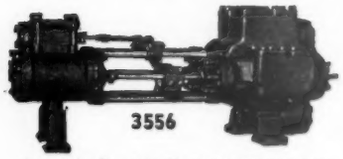

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the well as "abandoned" even though it is the intent of the operator to return to the well and drill it deeper. This is not, therefore, considered a serious error. If and when these two wells are drilled deeper, they will again be picked up on reports as an "old well drilled deeper," or what is commonly known as "OWDD," and exploratory footage will be added and credited to well.

Paul H. Umbach

Consulting Geologist
Albuquerque, New Mexico

Gas Blowouts

To The Petroleum Engineer:

In The Petroleum Engineer, Volume 19, No. 5, February 1948, I have read a very interesting report entitled "How High Pressure Gas Blowouts in a Texas Field Were Brought Under Control" by K. Marshall Fagin.

As I am just writing a book about oil and natural gas, which will be soon published by Ulrico Hoepli, I should be very obliged to you if you could procure me some of the glossy photos reproduced on the above report and the permission to publish them together with a short resumé of the report.

If the photos are not in your hands, please forward my request to The Magnolia Petroleum Company. I cannot write directly to the above company as I have not their address. I apologize therefore for the trouble I am giving you and thank you warmly for your kind assistance.

Mariano Amico

President of Societa Anonima Imprese Perforazioni
Via dei Valeri, 1 — Rome, Italy

Anadarko Basin

To The Petroleum Engineer:

Enclosed please find my personal check for $3, which I believe will cover a two-year subscription to the Drilling and Producing edition of *The Petroleum Engineer*. I would like to have my subscription begin with your recent November issue, as I am very interested in the articles concerning the Anadarko Basin.

I've seen your magazine several times and have just neglected putting in my subscription into it. However, as time goes on I find that the caliber of articles which you include make it essential that your magazine be one of the musts for me.

David B. Remick

Chief
Geological Department
Pan American Production Company
Houston, Texas

☆ ☆ ☆

In 1939, in its first full year of operation, the Wage and Hour Division of the Department of Labor spent $1,044,165. Estimated expenditures for 1952 are $8,704,300 eight times as great as in the first year—or enough to pay 2575 factory workers $65 a week for one year.—*Tax Outlook.*

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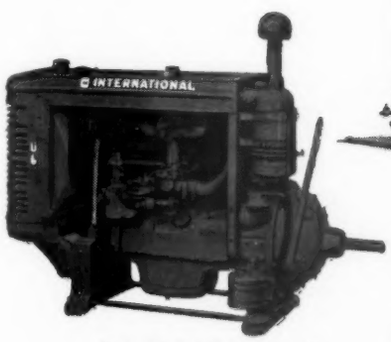

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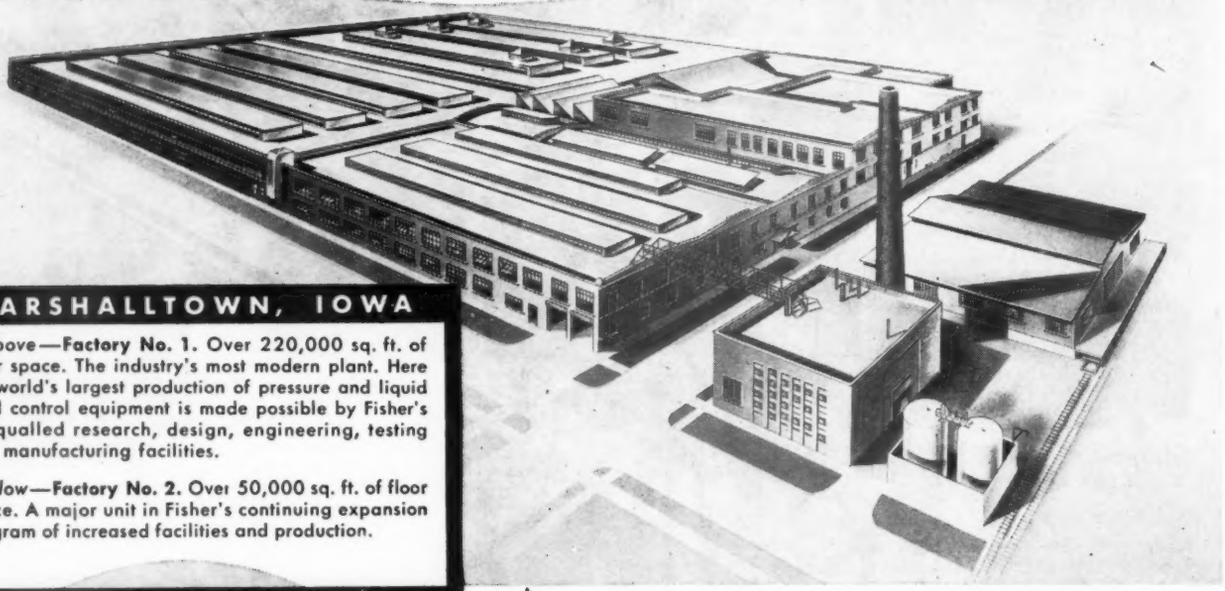

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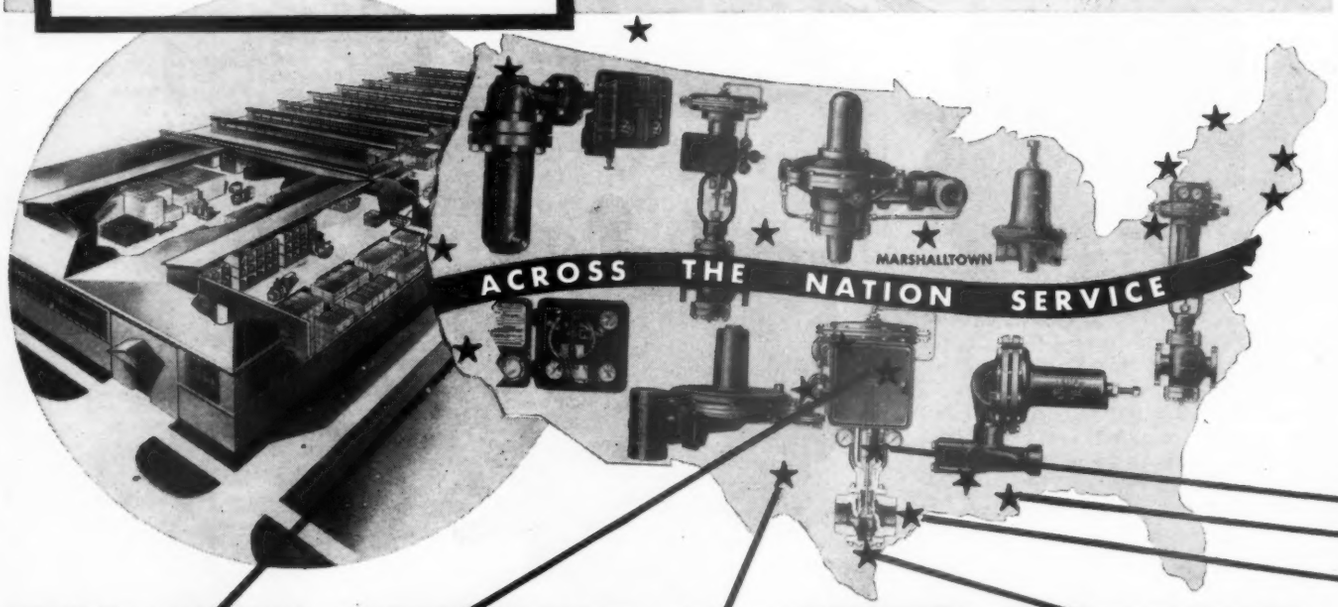

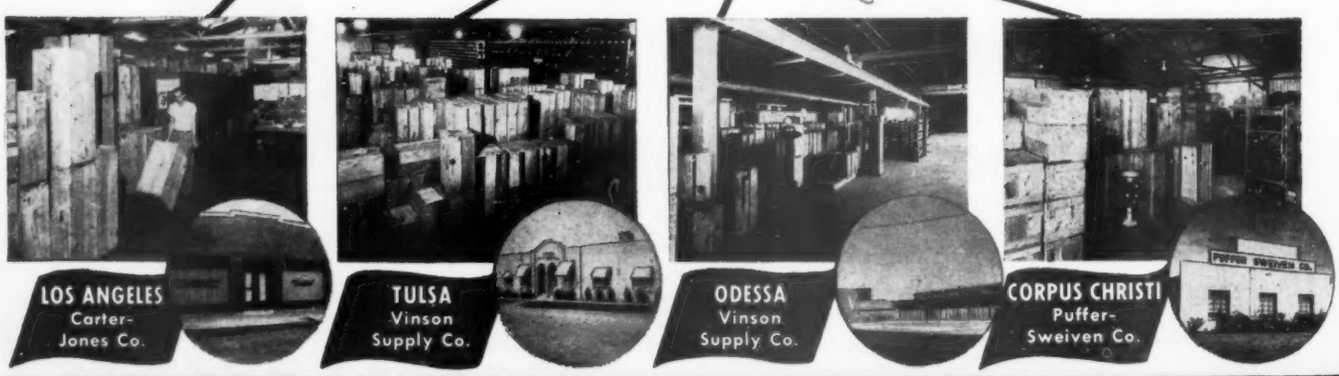

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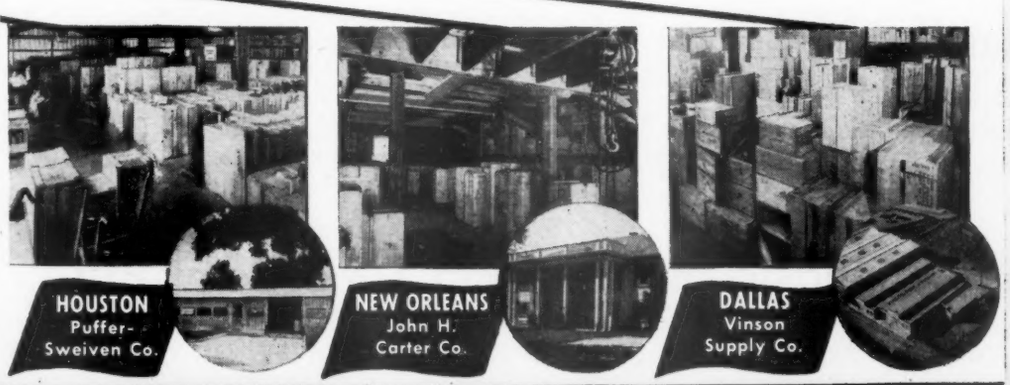

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Whose cheese is being divided?

TWO cats could not agree on fair division of a tasty cheese. "Let's go to the monkey," said one, "He is all-wise and can divide our cheese fairly." So to the monkey they went.

The monkey immediately broke the cheese evenly and judicially put the two pieces on the pans of his balance. But one was slightly heavier. He shrewdly nibbled that piece a bit and put it back on the scales. Now it was the lighter piece. So he bit off some of the other piece only to find it the lighter. Thus while the two hungry cats watched, the monkey kept taking bites of the cheese, first one piece, then the other, until finally the cheese had almost disappeared.

"What's left is too small to divide," sagely pronounced the monkey, as he popped the remaining fragments into his mouth.

Observers of the American scene see a direct parallel between the record of federal taxation and this ancient parable of the trusting cats, the greedy monkey and the cheese. Business and the individual citizen have been content to trust government to rule on the disposition of their earnings. And Uncle Sam keeps taking bite after bite out of the shares of both individual citizen and business.

Already government bites are so large as to severely penalize citizens and business alike. If allowed to continue, it will seriously impede further industrial progress and growth, stifle initiative and threaten the strength of our free enterprise system. Beware the day—goal of the socialists among us—when the monkey says, "What's left is too small to divide."

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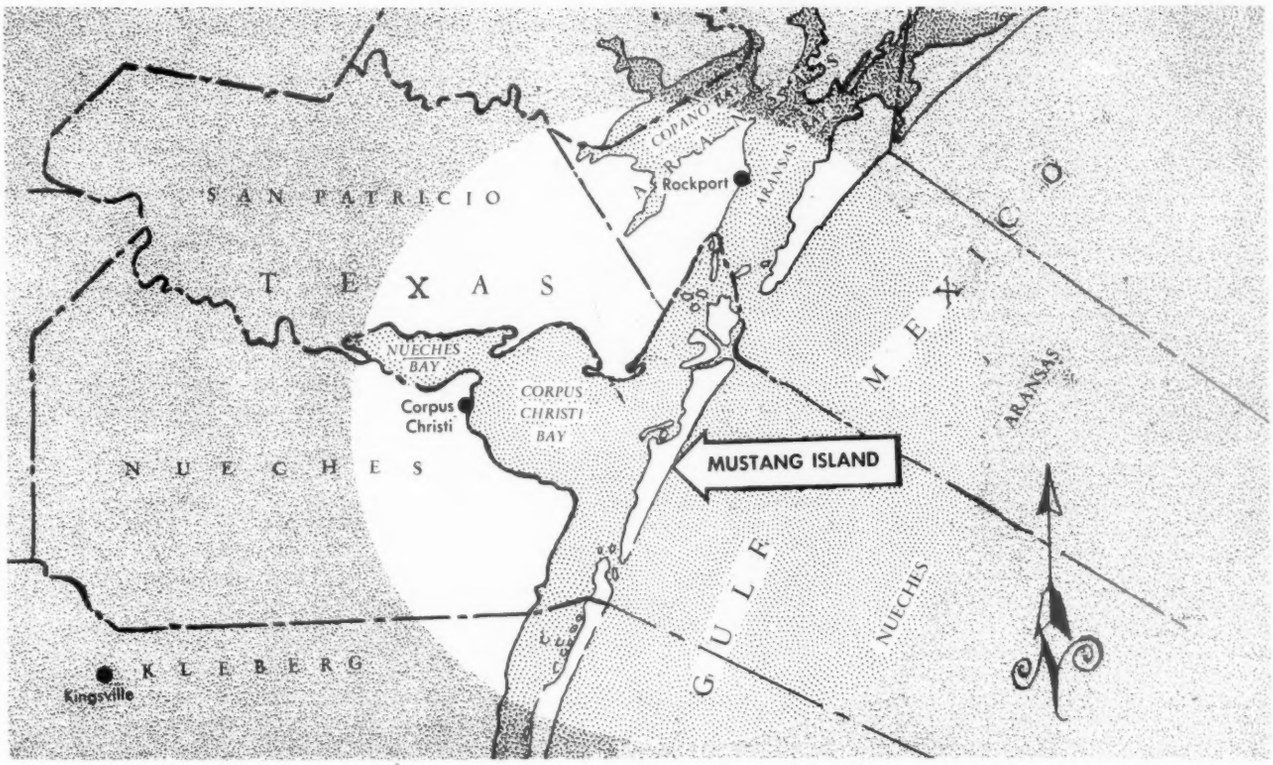


P 400

MUSTANG FIELD

Wells cost more in this offshore area but there are five oil and two condensate reservoirs to go after

G. V. RICKS and J. M. DAVID

MUSTANG ISLAND multi-zone field is in Corpus Christi Bay, Nueces County, Texas, 14 miles east of the city of Corpus Christi. The field is a faulted anticlinal structure producing from a series of Marginulina-Frio Oligocene sands found at depths from 6800 to 7800 ft.

The Atlantic Refining Company and Tide Water Associated Oil Company jointly owned State Tract 436 No. 1, was the discovery well in the field. It reached a total depth of 9525 ft on February 15. 1949. The well was spudded November 12, 1948. Seven-inch casing was set at 7514 ft and 5-in. OD liner at 9000 ft. Two sands at 8800 ft and 8840 ft were tested and each produced salt water. The next test on the well at 7600 ft resulted in the production of gas and distillate. After several tests in this gas reservoir, now designated as the Sand 5 gas reservoir, the perforations were squeezed. Oil production resulted from the next test on the well at 7435 ft, this oil zone being named Sand 6. On an eight-hour test the well flowed at the rate of 46 bbl of 41 deg API gravity oil with a gas oil ration of 1500 to 1 and a tubing pressure of 550 psig. After several days of testing, the well died and was subsequently recompleted and is now producing as a gas-distillate well in the Sand 5 gas reservoir.

Drilling, completing, and equipping costs are exceedingly higher in the Mustang Island field than those encountered in normal oil or gas field development, due to the offshore location of the field Practically all wells are drilled from submergible drilling barges, which in many instances required a considerable amount of dredging to permit entry of the drilling barge into a well location. Drilling and completing costs are roughly $60,000 more per well in these water locations than would be required for a similar well located on land. Some twin well drilling has taken place in the field and two wells that are situated on land have been dually completed. Because of hazards involved, no dual completions are being made on wells located in the water. Normal completion practice is to set casing through the deepest pay zone, perforate, test, and run completion equipment. All singly completed wells have the tubing set with a packer and the tubing-casing annulus filled with mud.

There are five oil reservoirs and two gas condensate reservoirs being pro-

EXCLUSIVE

The Authors

G. V. Ricks

J. M. David

G. V. Ricks is a senior production engineer for the Atlantic Refining Company. A graduate of Texas A. & M., he received his BS degree in mechanical engineering, and joined Atlantic in Dallas, Texas, in 1948. Since joining Atlantic he has ben associated with various phases of production engineering, and was appointed to his present position in May of 1952.

J. M. David is regional reservoir engineer for Atlantic in the Southwest region, Corpus Christi, Texas. David attended Tulsa University from 1941 to 1943 when he joined the Naval Air Corps as a pilot. He left the Air Corps in 1946 and received his degree from Tulsa University in 1949 at which time he joined Atlantic.

duced in the field. (Fig. 1). These reservoirs in order of depth are Sand 10, gas; Sand 9, oil; Sand 8, oil; Sand 7-A, oil; Sand 6, oil; Sand 5, gas; and Sand 11, oil. Fig. 2 is a typical electric log of the Mustang Island field showing the productive section. All sands with one exception are separated from the nearby Redfish Bay field. Sand 10 is the only reservoir continuously productive over both fields. The water-oil contacts, which have been established for the majority of the reservoirs, appear to be fairly uniform over the extent of the field for each reservoir except in the area of Sinclair's State Tract 406, where a variance of some 60 ft with the remainder of the field has been noted. No significant variance of gas-oil contacts has been found. The sealing faults on the northeast and southeast portions of the field vary in displacement from 150 ft to 500 ft.

Field rules have been promulgated for all reservoirs in the field with the exception of Sand No. 9. Spacing for the oil reservoirs has been established at 40 acres per well with allocation of oil allowables based 50 per cent on acreage and 50 per cent on per well. Spacing for the gas reservoirs has been established originally at 320 acres per

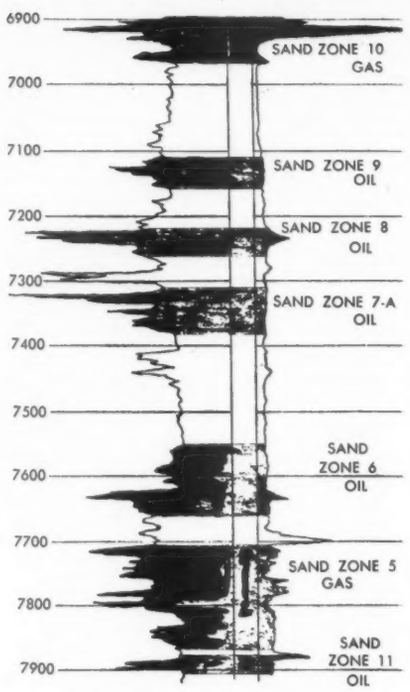
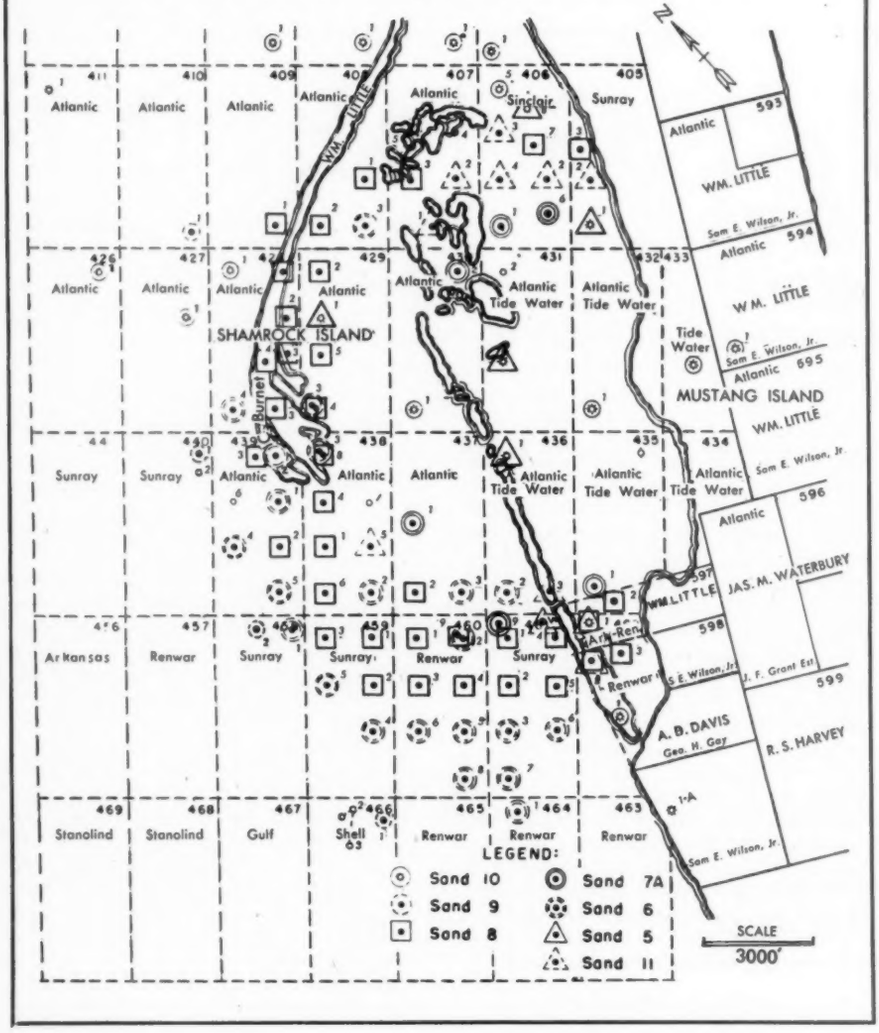


FIG. 2. Typical electric log. Mustang Island field.

FIG. 1. Completion map, Mustang Island field, Nueces County, Texas.



well with allocation based on productive acreage times bottom hole pressure. This spacing of gas wells was due primarily to the size of the tracts in the field and to the fact that the state tracts were separate leases that could not be unitized with one another. Recent legislation has been passed which permits the unitization of state leases. Consequently, the operators in the field requested and the Texas Railroad Commission has promulgated rules specifying 640-acre spacing with allocation of gas allowables based 75 per cent on productive acreage and 25 per cent on per well for the Sand No. 10 gas reservoir, productive in both the Mustang Island and Redfish Bay fields. Three wells producing from a small Sand 10 reservoir separated by faulting from the main Sand 10 reservoir have remained on the original 320 acre spacing. There is now pending before the Texas Railroad Commission a request for 640 acre spacing for the Sand 5 gas reservoir.

Subsequent to discovery of the field, extensive development has been carried on for both oil and gas production. The July, 1952, proration schedule shows the following number of wells completed in the various reservoirs.

Sand	Number of gas wells	Number of oil wells
11	..	9
10	17	..
9	..	1
8	..	35
7-A	1	5
6	..	21
5	5	..
Totals	23	71

Development of the field is still in progress at the present time.

Gas Production

Conclusion of a gas sales contract in February, 1950, for the sale of Atlantic's gas production from the Mustang Island field necessitated the development of a method for handling this gas production, and after study and economic analysis, it was decided to collect the gas at a central location through high-pressure gathering lines from the various wells. The use of a central plant operation was particularly attractive due to the marine location. The Gas Transmission Company laid a 12-in. line into a sales location on Tract 436, and the high-pressure gathering system from the various wells was laid to this point. Fig. 3 illustrates Atlantic's present gas gathering system. Welded Schedule 80 Grade B seamless pipe coated with a coal-tar base pitch and asbestos pipe line felt wrap was used throughout the system.

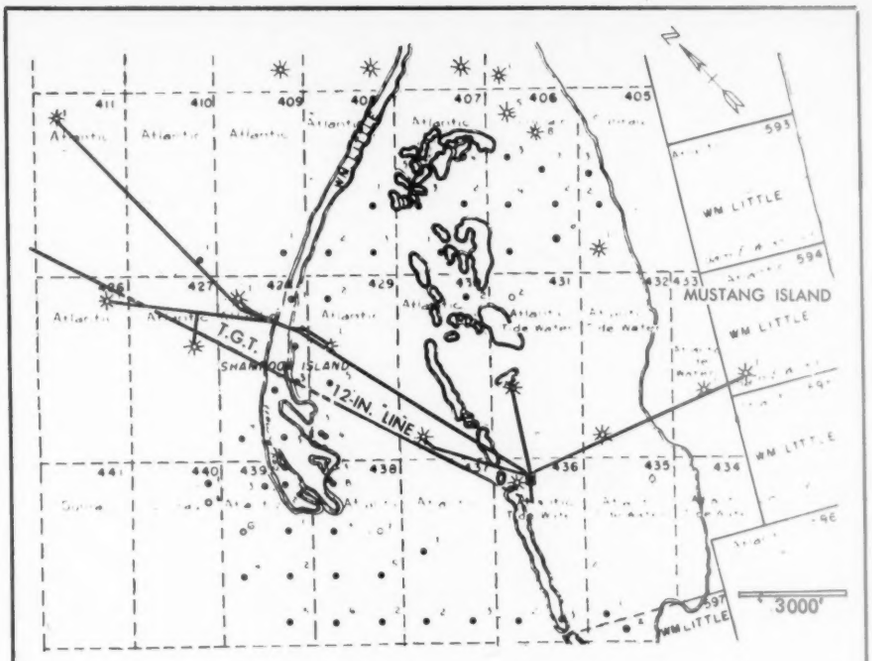
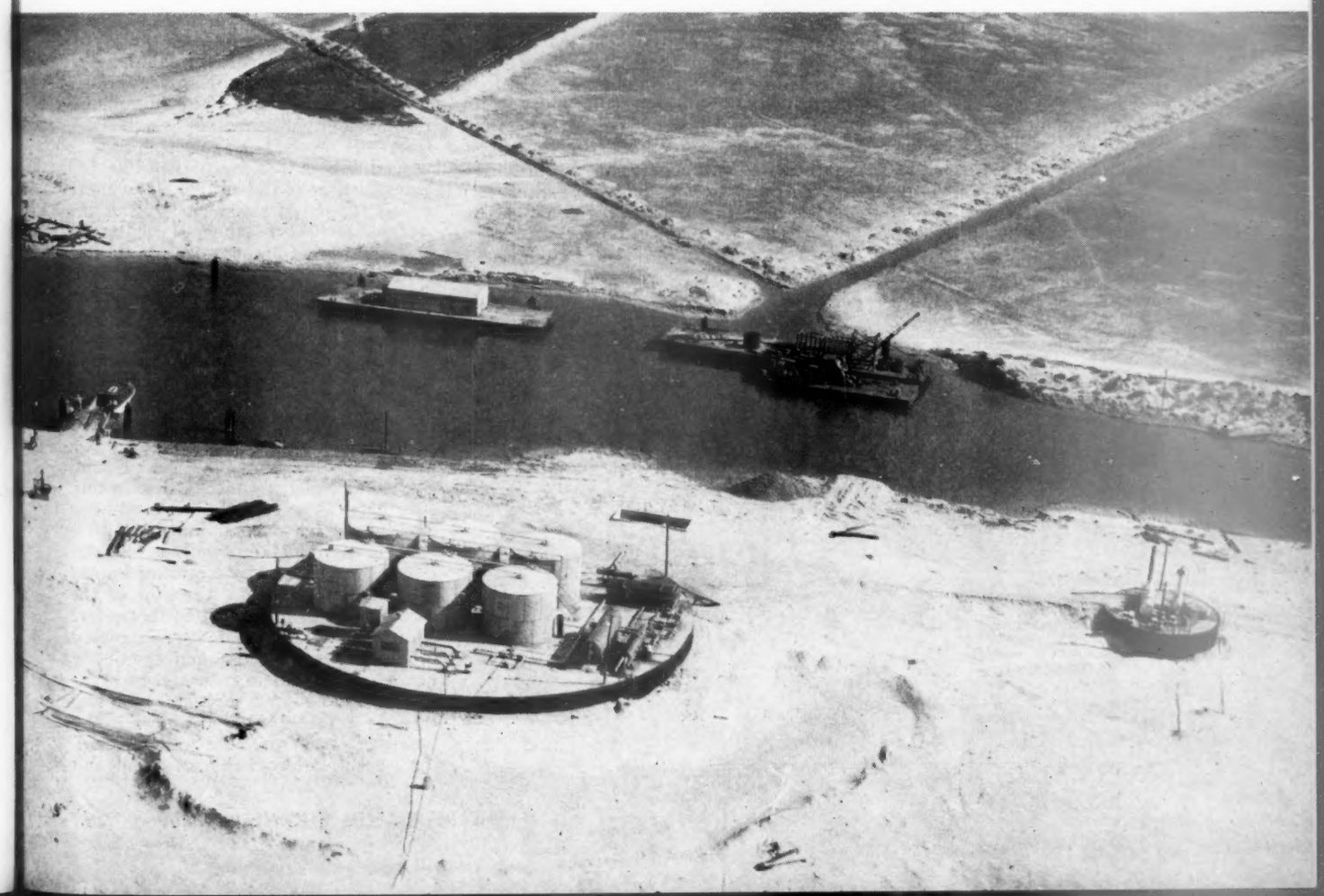


FIG. 3. Atlantic's gas-gathering system at Mustang Island.

Low Temperature Separation. Considerable development work has been done during the past several years on low temperature gas separation equipment. This installation offered an ideal opportunity to combine known methods of field-wide high pressure gas gathering with a new development in low temperature separation equipment. The original low temperature separation installation is shown in Fig. 4. The installation is located on the tidal flats off Mustang Island in State Tract 436. In order to protect the equipment from water and wave action during storms, the installation was placed on bulkheads which are approximately 8 ft above the level of the island. A 125-ft diameter bulkhead was constructed for the storage tanks and separation equipment and a 36-ft diameter bulkhead was constructed approximately 150 ft from the battery bulkhead for the heater and glycol reboiler. These bulkheads were constructed of 3 ft by 8 ft timbers, 12 to 16 ft long. Approximately one-third the length of these timbers was driven into the ground. Steel rods 1½-in. in diameter hold the structure together somewhat like a wood tank. The interior was filled with shell and earth topped off

FIG. 4. Original low temperature separation installation is on tidal flats off Mustang Island.



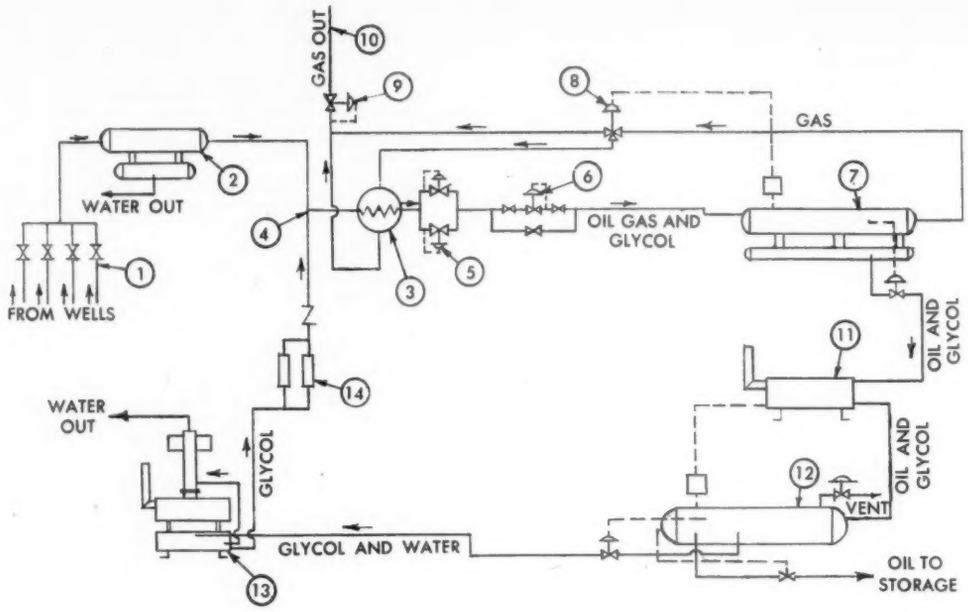


FIG. 5. INITIAL GLYCOL LOW TEMPERATURE SEPARATION INSTALLATION.

with shell. Fig. 5 is a diagrammatic sketch of the layout of the equipment installed. Numbers on the sketch in Fig. 5 will be referred to in this discussion to point to the various items of equipment. Gas is led from the high pressure gas gathering system through a high pressure manifold (1) to a high pressure free water knockout (2). Here the liquid water is removed and the gas passes to a high pressure heat exchanger (3). Cold gas from the separator is led back through this heat exchanger to pre-cool the high pressure wet gas. Glycol is injected into the flow line (4) to prevent the formation of hydrates in the heat exchanger. The gas leaving the heat exchanger passes through two high pressure back pressure regulators (5) that maintain approximately 2200 to 2500 lb pressure on the gas gathering system, free water knockout, and the heat exchanger. From the heat exchanger the gas goes through regulator (5), valve (6), which is a safety valve that will close if more than 1000 lb is placed upon the high pressure separator. Leaving valve (6), the gas goes through high pressure separator (7) which is of a horizontal type and was especially designed by the manufacturer for this application. Normally this separator operates at a temperature of approximately 10 F. Temperature on the separator is controlled by a thermostat which controls in turn the operation of the three-way bypass valve (8). This valve allocates cold gas to the heat exchanger as needed to maintain the temperature for which the thermostat on the high pressure separator is set. The gas leaving the low pressure separator, after passing through the three-way valve and then either to the heat exchanger or direct to sales, goes through the regulator valve (9). This regulator valve maintains a constant pressure of 800 lb on the high pressure separator regardless of the pressure in the gas gathering system. After leaving valve (9), this gas goes to the metering station (10) and then to the transmission company's main line. The mixture of condensate and water at 10 F is dumped from the high pressure separators through heater (11) where it is heated to approximately 80 F and then flashed into a low pressure separator (12). The separator is equipped with a double dump system that dumps the water and glycol to the glycol reboiler (13) where the water is removed and dumped to the pit and the glycol returned to the glycol recirculation system and reinjected by the glycol pumps (14) which are a 4 by 5/8 by 8-in. pumps run by high pressure gas. Condensate from the second stage separator is flashed into a battery of six 1000-bbl galvanized bolted steel tanks and there stored for barge shipment. During the summer of 1951 a rather detailed series of tests were run on this installation, results of which are shown in Table 1. From these tests it can be seen that the additional recovery attributed to this type of separation is approximately 25 per cent over what could have been obtained with conventional stage separators.

In May, 1952, the flowing pressure had dropped on the three wells, Sam E. Wilson No. 1, State 432 No. 1, and State 433 No. 1, to such a degree that they were not capable of producing against as high a water knockout pressure as the remaining wells in the system. The reduction of the water knockout pressure to permit the flow of the three low pressure wells into the system would have resulted in an increased separation temperature and thereby a decrease in distillate recovery. In order to maintain as low a separator temperature as possible and still permit the handling of low pressure wells through the system, a free water knockout and

TABLE 1.

Test number	1	2	3
Duration of test (hours)	72	24	24
Pressures (psig)			
Free-water knockout	2,250	2,250	2,250
High pressure separator	775	775	775
Low pressure separator	45	38	32
Sales gas	720	720	720
Temperatures (F)			
Free-water knockout	110	110	110
High pressure separator	18	30	46
Low pressure separator	82	82	82
High pressure heat exchanger inlet	110	110	110
High pressure heat exchanger outlet	77	88	101
Low pressure heat exchanger inlet	24	35	51
Low pressure heat exchanger outlet	96	101	104
Sales gas	82	72	65
Production			
High pressure sales gas (MMSCFPD)	21.159	21.382	20.924
Specific gravity	0.605	0.601	0.607
Dew point (F)	−13	+2	+13
Condensate (BPD)	354.7	348.0	327.0
GOR (SCF/bbl)	59,657	61,443	64,000
OGR (bbl/MMSCF)	16.76	16.27	15.62

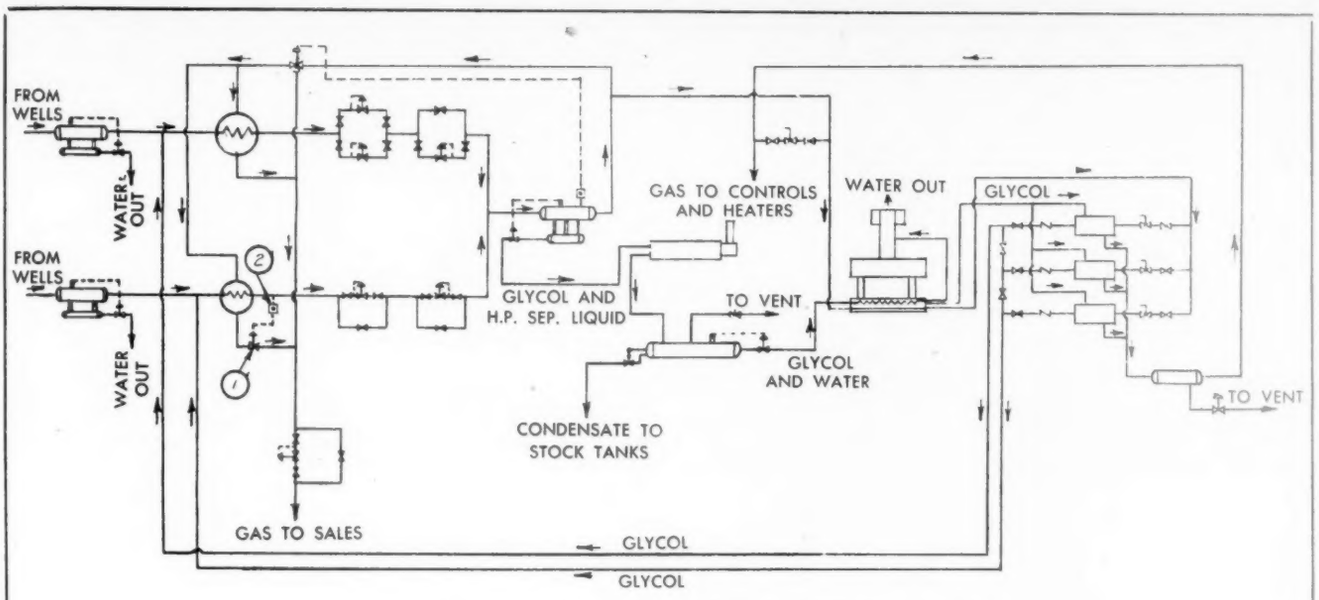


FIG. 6. GLYCOL LOW TEMPERATURE SEPARATION INSTALLATION.

heat exchanger was installed in parallel with the original knockout and heat exchanger. Fig. 6 is a diagrammatic sketch of this installation. Flow through this installation is the same as the previous explanation given on Fig. 5 with the exception that the flow of cold gas is prorated between the two heat exchangers. This is done by means of the control valve (1) which is controlled by the thermostat (2) located on the high pressure outlet of the low pressure heat exchanger.

Stabilization of Distillate. Plans are presently being made for the installation of a cold stream stabilizer in the plant to stabilize the distillate before it is flashed to the storage tanks. Fig. 7 shows the schematic arrangement of this contemplated equipment. It is anticipated that stock tank liquid recovery will be increased by 15 per cent with the installation of this stabilizer.

When this stabilization equipment is installed, the gas flow through the unit will be the same as in the previous installation except the gas after passing through the two gas to gas heat exchangers will pass through a gas to distillate exchanger to cool the distillate prior to its flow to the stock tanks. All the fluid from the high pressure separator will be dumped into the low pressure separator which will operate at approximately 350 psig. The glycol and water will be separated from the distillate in this low pressure separator and dumped to the glycol reboiler where it will be handled as explained in the previous installation. The distillate will be dumped from the low pressure separator into the cold stream stabilizer. The glycol absorbed by the distillate will be removed in this stabilizer and returned to the glycol reboiler. The distillate will be dumped from the stabilizer at approximately 300 F, passed through the gas to distillate heat exchanger and cooled to 90 F. From this heat exchanger, it will flow to the storage tanks.

The condensate production is pro-

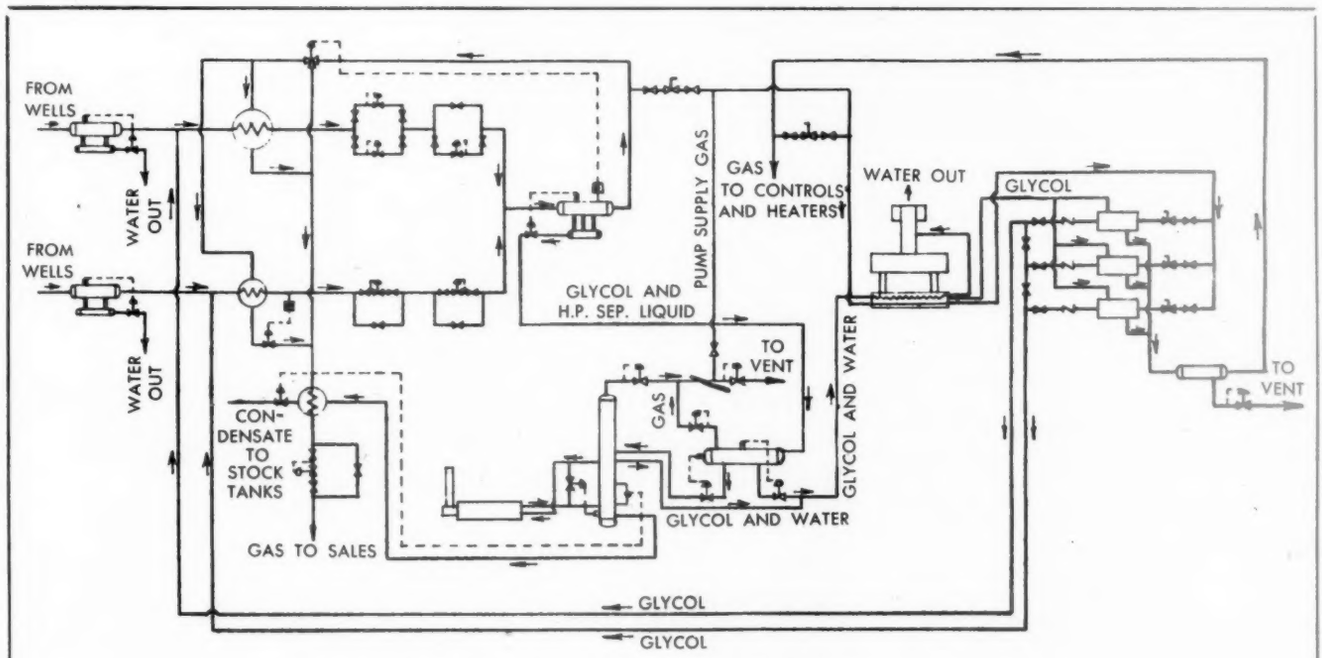


FIG. 7. GLYCOL LOW TEMPERATURE SEPARATION UNIT WITH STABILIZER.

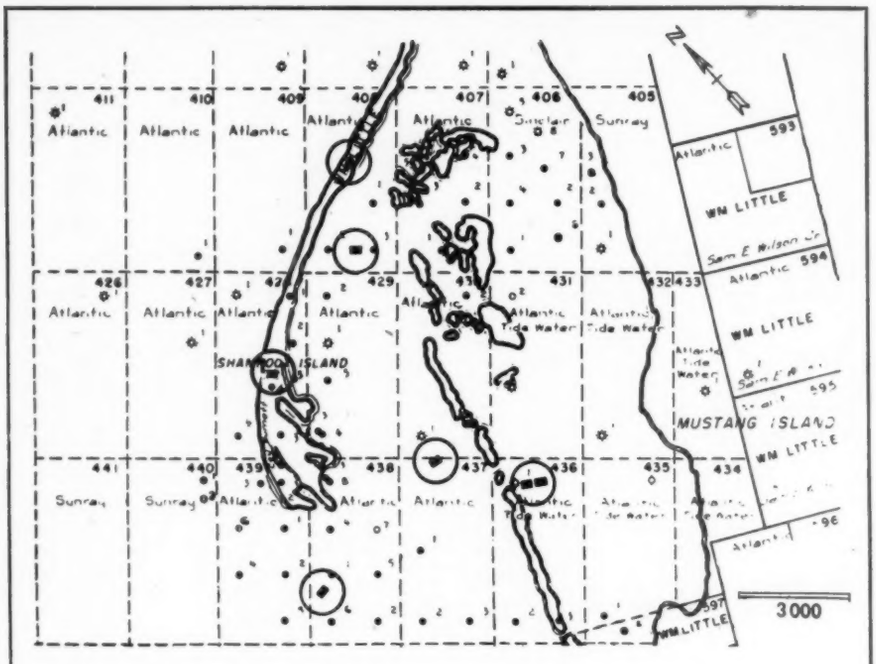


FIG. 8. Atlantic's tank battery locations at Mustang Island.

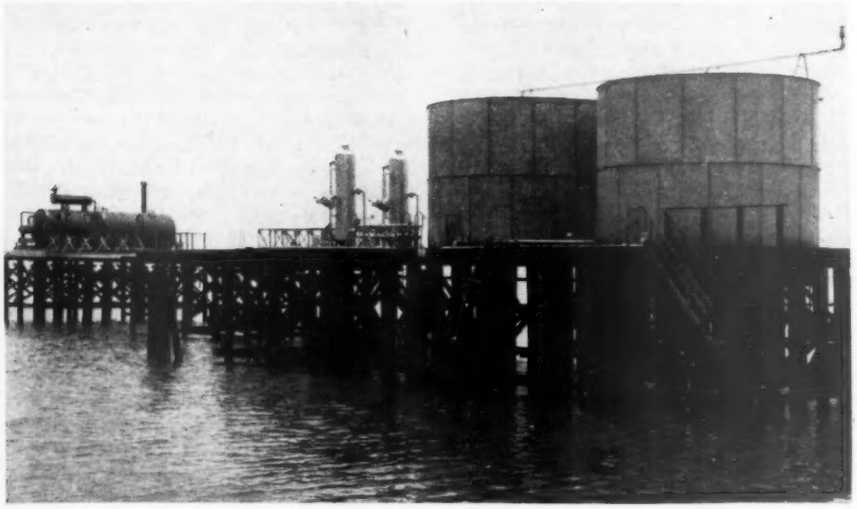


FIG. 9. First battery structure was made of timber in State Tract 408.

rated to the various wells on the basis of split-stream gpm tests which are run quarterly and the metered volumes from the wells. Meter runs are located at the wells on the well head platform. Each well is also equipped with a surface safety valve with a low pressure and high pressure shut-off to shut in the wells in case of line breaks or other failures.

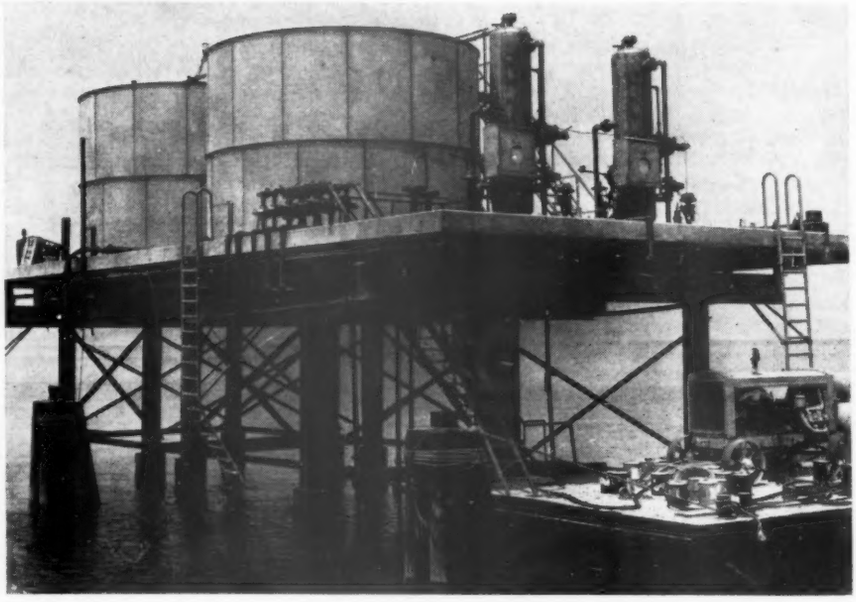
Oil Production

The handling of the oil production in this marine location presented an entirely different problem from that of handling the gas production. After study and economic analysis, it was decided that several batteries strategically located throughout the field would be much more satisfactory both from an operating and an economic standpoint than a large centrally located battery. The desirability of holding flow lines lengths to a minimum had a considerable effect on the decision for strategically located batteries throughout the field. Flow lines are very expensive to lay and maintain in this marine location. It was anticipated that large volumes of water would have to be handled during the artificial lift life of the wells and excessively long flow lines would result in future complications of the artificial lift problem. Also, it was desired to maintain individual flow lines to each well so that the wells could be tested, and with one centrally located battery this would have been expensive and caused an earlier need for artificial lift due to excessive pressure drop through the flow line.

Tank Battery Construction. Location of Atlantic Refining Company's batteries throughout the fields are shown on Fig. 8. Batteries were designed and constructed so as to have a reasonable chance of withstanding hurricanes. Since it had been observed that the major damage done during hurricanes in the Gulf was from wave action, the batteries were elevated above mean low tide so as to be safe from severe wave action during storms. The height of the batteries above mean low tide is shown on Fig. 8.

Pile Structures. The first battery constructed was the battery situated in the State Tract 408. This battery was a timber structure and is shown in Fig. 9. It has a timber deck and is constructed on timber piling. The deck is covered with roofing material and a 6-in. curb has been run around the edge to prevent oil that might be spilled on the deck from entering the water. When the wells producing into this battery began to make water, a heater-treater platform

FIG. 10. Steel piling was used for battery south of Shamrock Island.



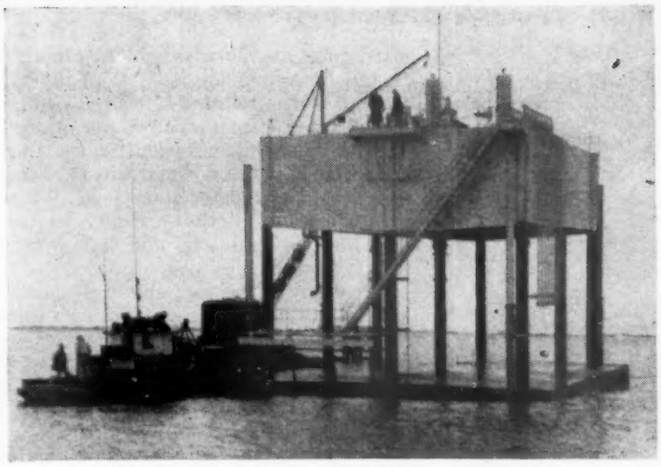


FIG. 11. Barge towed to position . . .

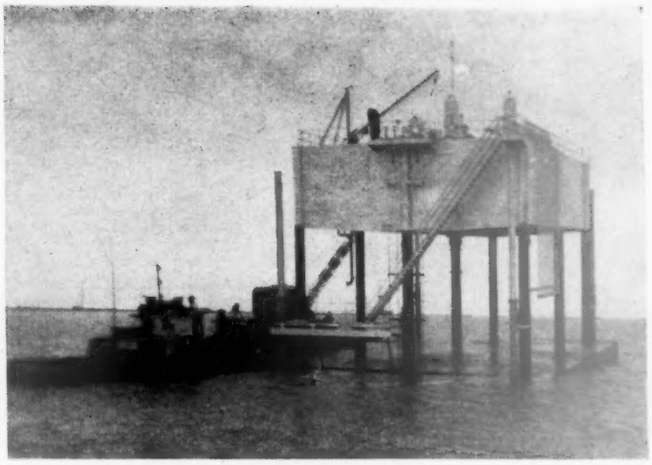


FIG. 12. Barge begins to sink . . .

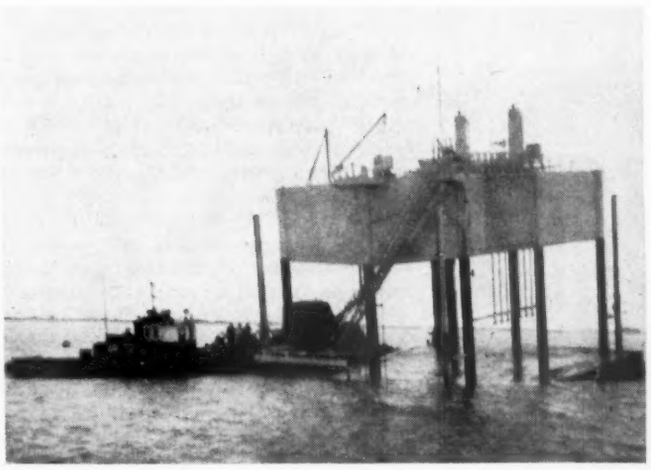


FIG. 13. Sinks farther . . .

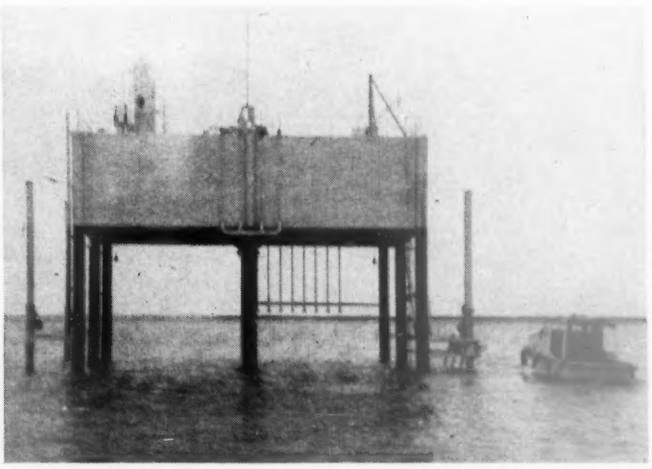


FIG. 14. Settles into position.

SUBMERSIBLE BARGE BATTERY

was constructed and a walkway run from the battery platform to the treater platform. This treater platform was constructed on timber piling. It differed from the battery platform, however, in that it had a concrete deck in order to minimize the fire hazard that would have been present with a timber deck. This battery provides 2000 bbl of storage.

When construction was begun on the second battery south of Shamrock Island, it was found that no sound bottom was available and piling of approximately 100 ft in length would be needed. Under these conditions, it was decided to use steel piling and construct the deck of concrete. This battery is shown in Fig. 10. Initially, this battery provided 2000 bbl of storage but was later increased to provide 6000 bbl storage. Later on a treater platform of the same construction of the battery platform was added to this location.

Submersible Barge Batteries. The third type of water battery utilized in this operation was a submersible tank battery barge. This battery is illustrated in Figs. 11, 12, 13, and 14. It consists of a 48 by 60 by 5 ft barge on which are six columns 20-in. in diameter. Atop these columns is the storage section. The upper section is 38 by 48 by 12 ft and is divided into four compartments of approximately 1000 bbl each. The separators, manifolds, and the necessary accessory equipment are mounted on top of the storage compartment. These batteries are constructed and equipped in the shipyards, towed to the location, and sunk by filling the lower barge with water. Fig. 11 shows one of the battery barges after it has been towed into position. Figs. 12 and 13 show the barge being sunk, and Fig. 14 shows it after it has settled into place. Locations for these barges are prepared by dredging out a slip and filling the slip with shell to give a level bottom on which to set the barge. The submersible sections of these barges are divided into four compartments. The barge is sunk by towing it into the location and then flooding the front compartment; when the front section is setting on bottom, the back two compartments are flooded and the barge settled into place. The first of these barges was sunk by flooding with sea water. The latter two were flooded with fresh water.

Land Batteries. In addition to the water batteries in this field, Atlantic has three batteries located on the islands. In the construction of these batteries, it was decided that they should also be elevated so as to protect the equipment from wave action during storms. Therefore, these batteries are constructed on a bulkhead. These bulkheads are 125 ft in diameter and are of the same construction as the LTS unit bulkheads. One of these batteries is shown in Fig. 15. The battery equipment on these bulkheads was erected according to Atlantic's standard plans for land batteries. The treater platforms for these batteries were constructed in the same manner as the tank battery bulkheads with the exception that they were of smaller diameter, being only 72 ft in diameter.

Battery and Treating Equipment. The battery equipment on both the bulkhead batteries and the platform batteries were constructed according to the company standard tank battery plans. In all these batteries 10 gage galvanized bolted steel tanks were used and were firmly attached to the structure. All the batteries are equipped with test separators and test manifolds. Safety devices

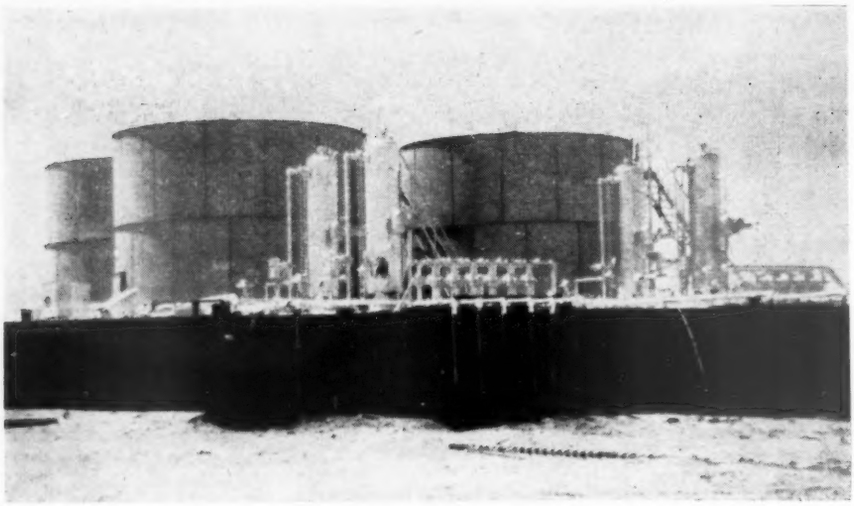


FIG. 15. Land batteries, like the one above, are constructed on a bulkhead 125 ft in diameter.

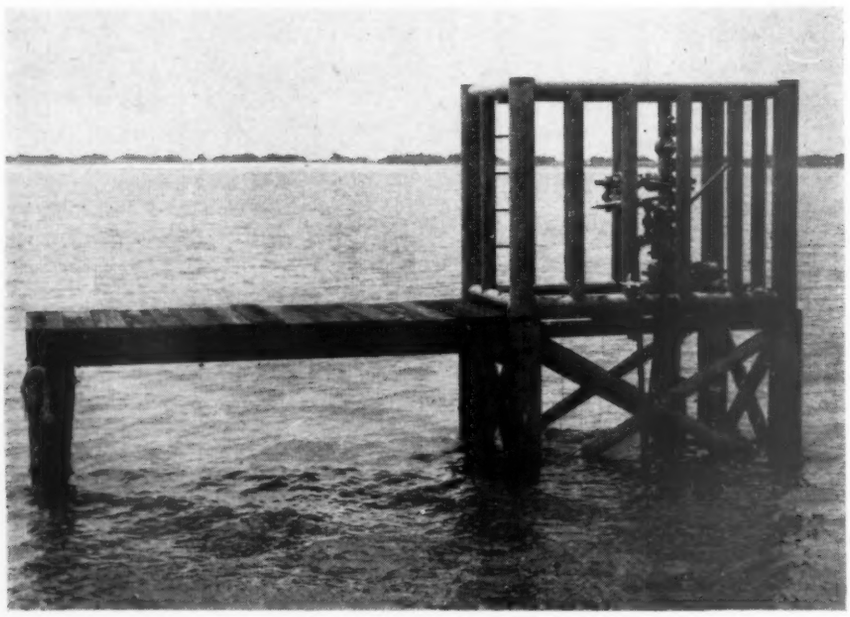


FIG. 16. Piling and cage protect the well heads from boats, barges, and drifting objects.

were provided in considerable numbers. Flow line safety valves were installed at each well with high and low shut-offs. Floats were put into the tops of the tanks so that when a tank becomes full, the action of the float will close the motor valve on the manifold flow line into the separator which would, in turn, raise the flow line pressure and shut the safety valves at the various wells. In addition, floats were placed in each separator to close in the motor valve on the manifold flow line in case the liquid level should rise above that desired in the separator. Double gas back pressure valves were provided on all separators so that the failure of one valve would not result in oil being sprayed onto the waters of the bay.

In all the treater installations horizontal treaters were used because of the more uniform load distribution they would provide on the platform. Also, their lower height would be inherently more stable than would a vertical treater. In order to prevent getting oil onto the water of the bay should the dump valve on the treaters fail to open, an oil skimmer was placed downstream of the water outlet of the treater. The oil dumps on these skimmers are tied to the flow line going back to the oil storage tanks. In order to protect against fire hazards, a motor valve was placed on the inlet line to the treater that would close if the downstream pressure dropped to a predetermined level. When this valve closes, the pressure in the flow line will build up and shut in the safety valve on the well head.

In order to protect the well heads from boats, barges, or any objects that may become adrift during a heavy sea, piling was driven into the bay around the wells and a steel cage placed in position as illustrated in Fig. 16. The piling and cage are made of 13⅜, 10¾, and 6-in. heavy steel pipes securely braced and reinforced. Two by 12 timbers were placed across the bracing of this cage structure to provide a timber deck around the well head. In addition, two timber piling were driven approximately 16 ft from the well head protective structure and a timber walkway provided from these piling to the well head structure. This provides each well with a boat landing and a relatively small work area.

Corrosion Protection

The protection of all this expensive and essential equipment from corrosion presents a major problem. Atlantic's corrosion engineers have made exhaustive studies of various types of protective coatings and are continuing with these studies both in the actual evaluation of performance in the bay and through laboratory evaluation. In order to protect them from the corrosive elements, all well head structures and submersible tank battery barges are coated before use with a 6-coat vinyl plastic system. The well heads themselves are coated with a non-hardening grease-type coating. All flow lines are coated with three coats of plasticized coal tar enamel, one wrap of fiber glass, and one wrap of asbestos felt. On the tank batteries only galvanized bolted steel tanks are used. All separators and other surface lease equipment operating at atmospheric temperature have been sandblasted and coated with a four-coat vinyl system. All the piping above water is wrapped with an asphalt impregnated cloth or reclaimed rubber compound and coated with aluminum paint. In addition to this, Cathodic protection has been widely used to protect all structures, barges, well heads, etc., that are below the water level. Steel piling in the battery structure in Section 438 was coated with vinyl plastic 6-coat system after erection. The steel piling were protected at the water level and splash zones by use of a concrete caisson type covering poured after the piling was driven. It is anticipated that a continuous maintenance program and repainting and recoating of these structures will have to be maintained in this area. It is not anticipated, however, that underwater corrosion will be a problem but mainly that protection will be needed at the water level in the splash zone. ★ ★ ★

☆ ☆ ☆

Callon Completes Well In Mississippi County

John S. Callon, independent operator, has completed his No. 1 Hodges in Adams County, Mississippi, with a flow of 360 bbl of oil per day. The new well, which opens a new field, will be under river water when the river is high. Hole was drilled to 7013 ft, and was cased with 5½-in. casing to 6250 ft for the completion. Production is from casing perforations 6200-04 opposite top of a 14-ft oil sand electrically logged in the Wilcox formation at 6200-14 ft.

Subsurface Storage of Liquid Hydrocarbons*

Dependent on product stored and market price at recovery date, savings effected should establish a payout in less than five years

NEAL E. VAN FOSSAN

ANY constant flow producing installation is, at one time or another, faced with the crisis of demand fluctuation. This is especially true of the LPG industry. Demand exceeds supply during the winter months as a large proportion of the product produced is used in heating loads. Conversely, supply exceeds demands during the summer when heating loads are not acute.

The above statement applies to butane, propane, and butane-propane mixtures. Several other factors complicate the problem. Legal regulatory action to relieve over-production has been based or gas output. The demand for residue gas is not in direct relationship to that for the propanes and butanes. Royalty payments are made on the basis of LPG product sold. Natural gasoline, a further product of the stripping process, has a constant and lucrative market. The oil producer, who supplies the raw product, reaps more benefit from the oil produced, regards the LPG as a by-product, and resents any curtailment of production from his wells.

The situation then exists that constant flow is desirable, but constant demand is absent.

Well—one could burn the stuff, many gallons have gone up in smoke during the time of low demand. This most evidently is a loss not only of future marketable product, but also a loss to the oil producer and land owner in royalty payments. A portion of the excess LPG could be passed to the residue gas line; however, the value of gaseous LPG in that arrangement would be in the vicinity of 1/28th its market value in liquid form.

The logical answer is, of course, storage. Store the excess product until demand comes abreast of supply. Unfortunately, propane must be stored under pressure. Such surface pressure storage costs about $20 per barrel. As an example, a certain West Texas plant has a daily production of 70,000 gal of LPG —in an 180-day span, during the low demand period, 6,300,000 gal of product was flared or sold as residue gas. Surface pressure storage, for this volume would cost more than $3,000,000. The pay out on such a low value product would be a long range one.

Several attempts have been made to store LPG in underground reservoirs with varying degrees of success. Previous projects have involved usage of depleted oil and gas reservoirs, or water sand formations having proper contours to hold fluids without migration. Loss and contamination have been major problems.

Caverns, either natural or artificial, have been successfully utilized. The development of an artificial cavern is expensive; also it is rather difficult to get a good tight one. The sealing of natural caverns to hold 200 psi is quite difficult.

Seemingly, the most feasible underground storage idea, in the light of economics and wide application, was pioneered by H. C. Billue, formerly with the Sid Richardson Gasoline Company, and now acting as a consultant on such problems. Billue proposed to wash a cavity in the soluble salt strata that exists in practically all marine sedimentary basins. Several factors limit the application. The salt section must lie at sufficient depth so that cavity ceiling overburden pressures will be in excess of injection pressure. Normal overburden pressures would probably be in the vicinity of 1.1 lb per foot of depth, and a presumed cavity ceiling injection pressure of 700 psi would require an overburden of approximately 750 ft. The salt section should be of sufficient thickness to give the required storage volume. The salt section should have an overlying impermeable formation. It must not contain continuous permeable stringers that would permit loss by migration. Adequate supplies of fresh water (approximately 6 bbl per barrel storage) must be available.

The first full scale storage installation was formed in the Benedum field, Upton County, West Texas, at a plant owned by the Upton Gas Products Company and operated by the Texas Gas Products Company.

The Upton Gas Products Company had completed construction, and put into operation a stripping plant in the Benedum field, in October, 1949. They were immediately faced with the storage problem.

G. C. Tompson (production engineer for the Slick-Urschel Oil Company), John Oxley (president of the Texas Gas Products Company), and other members of each organization, made a thorough study of the storage problem. In the course of their investigation it was decided that Billue's storage idea seemed the most practicable. It was agreed that such a project would be attempted at the Benedum plant.

Method

A number of logs were available from oil wells in the vicinity of the plant. After study of the logs, a location was picked, about 100 yd north of the plant proper. Surface casing was set at 324 ft and a casing string was set in the Rustler anhydrite at 1284 ft. Cement was circulated behind both strings. A 6⅛ in. hole was drilled from under the casings to a total depth of 2000 ft (approximately 700 ft into the salt section). The hole was static pressure tested. Cores, electric log surveys, and caliper surveys indicated the open hole section to a total depth, to be predominately salt with a few shallow anhydrite stringers. The thickness of the salt section was approximately 1500 ft.

Two and one-half inch tubing was run to within 10 ft of total depth and circulation was started in the normal manner; tubing to hole with returns through the casing to the surface. Circulation was reversed at intervals in an attempt to control the cavity shape. Certain facts should be recognized in circulating the hole. Reverse circulation will have a tendency to wash behind the casing with subsequent dangers of undermining the casing seat and possibilities of com-

The Author

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*Partially taken from a paper presented at ASME conference, Kansas City, Missouri, September 1952.

EXCLUSIVE

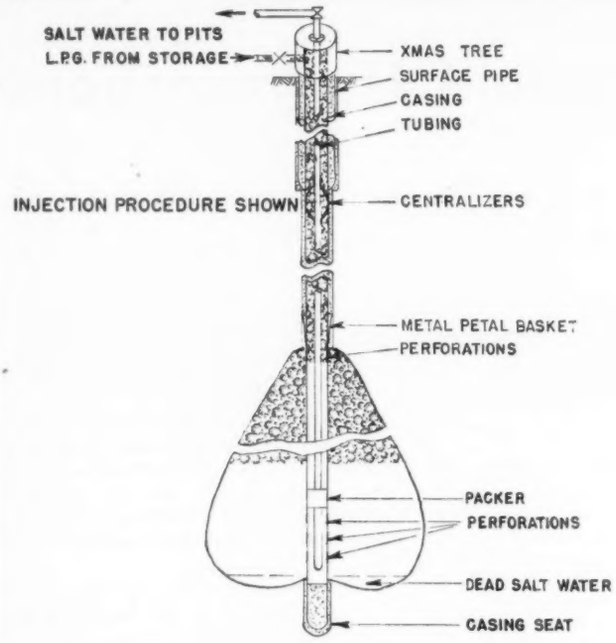
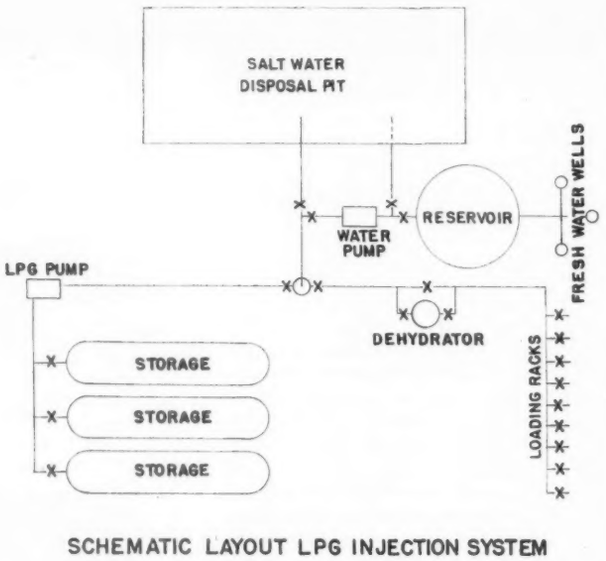


FIG. 1



SCHEMATIC LAYOUT LPG INJECTION SYSTEM

FIG. 2

munication to a higher thief zone. Constant checks should be maintained for loss of returns.

It should be of general interest, at this time, to outline a proposed casing program that would probably prove superior to the one used on the original well. Surface pipe would be set to a depth dependent on local water sand requirements. The hole drilled from under the surface pipe should be as large as possible. Hole should be drilled to a substantial stringer in the base of the salt section. The next step would be to run a production string to total depth and cement with a two stage job. The lower stage to be mixed with salt water. It is assumed that salt water cement will form a better bond with the salt section and be less liable to erosion during the washing operation. Extreme care should be exercised in figuring volumes of cement required on the lower stage because the greater the fill the less will be the available washing section. The upper stage would be circulated to surface through a staging collar set slightly above the top of the salt section (preferably in the impermeable stringer). It would be advisable to place a metal petal basket immediately under the staging collar to prevent any cement setting into the proposed cavity area.

After the cement sets up, the staging collar would be drilled out and the casing scraped clean down to the float collar on top of the bottom joint. (The ideal situation would exist if the fill would just reach to this point.)

The production string would then be perforated, above the cement, in the lower section of the salt. At this time a production packer (without a latching device) would be set above the lower perforations. The upper perforations would be shot at the ceiling of the salt section. Tubing would be run and set with weight on the packer. It would be advisable to run spring type tubing centralizers at about 100-ft intervals.

Well History

Now to return to the history of well No. 1. Fresh water, at surface storage temperature, was pumped to the proposed cavity area and hourly records maintained of percentage saturation and rate of flow in and out. The average percentage of saturation was found to be in the vicinity of 90 per cent. The percentage saturation obtained by washing is, of course, dependent on several factors; the solubility of the structure itself; the area exposed to washing and the rate of flow of the washing medium. With constant flow, percentage saturation increases with cavity volume because of the area factor. Even under increasing area conditions, presuming a plentiful fresh water supply and sufficient pump capacity, a certain limiting rate of flow will be reached beyond which percentage saturation will fall off. Attempts have been made to increase wetable areas by blasting and shattering the salt section. The dangers of such procedures, used under improper subsurface strata conditions, should be evident.

An interesting variation in washing procedure would be to have salt water disposal wells (or a water flooding project) and wash from fresh water wells, to cavity area, to salt water disposal wells.

Calculations

Calculations for storage formed per barrel of water pumped were based on the following figures:

a. Assure all salts are NaCl

b. For 100 per cent saturated solution 36.2 lb of salt will be dissolved in 100 lb of water

c. Fresh water weighs 62.4 lb per cu ft = 349 lb per barrel

d. The specific gravity of rock salt is 2.17

e. Therefore:

$$2.17 \times 6.42 = \frac{135 \text{ lb of salt}}{\text{cu ft of storage}}$$

$$= \frac{758 \text{ lb of salt}}{\text{bbl storage}}$$

f.

$$\frac{\dfrac{36.2 \text{ lb salt}}{758 \text{ lb salt}}}{\text{bbl storage}} \times \frac{\dfrac{349 \text{ lb water}}{\text{bbl water}}}{100 \text{ lb water}}$$

$$= \frac{0.1675 \text{ bbl storage}}{\text{bbl water}}$$

g. Thus 5.97 bbl of water are required per barrel of storage cavity formed.

A storage reservoir of 2,492,700 gal (volume based on calculations previously discussed) was developed in 63.87 net circulating days. The average daily enlargement was 929.21 bbl or 38.71 bbl per hr. At a later date 2,086,500 gal of propane were injected into the well and, taking into account the dead salt water area existing between the bottom of the tubing and base of cavity, it would appear that the basis of estimate was within 5 per cent accuracy. Approximately a total of 354,000 bbl of water was required to form the cavity.

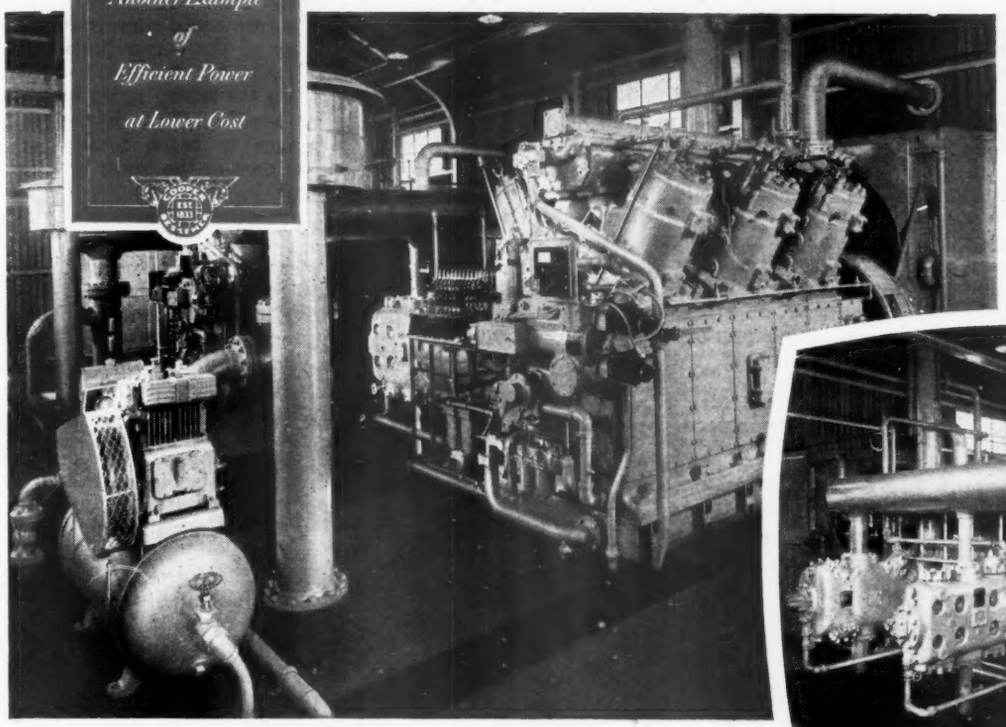
The cavity shape has not been definitely determined. Surface injection pressures versus volume fill studies indicates the shape to be that of an hour glass roughly 15 ft at its neck and 30 ft at the top and bottom. Periodic reversals of circulation could produce such a shape.

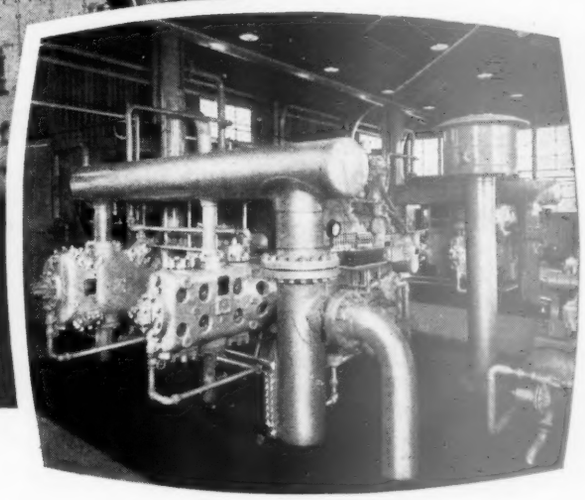
It should be understood that cavity shape will be greatly influenced by insoluble stringer configurations in the salt section.

Costs

The actual cost per barrel of storage formed will fluctuate rather widely as

Another Example of Efficient Power at Lower Cost





Left: Two Cooper-Bessemer skid-mounted GMX-6 compressors in Lone Star's Abilene Booster Station. Station is piped for either east or west delivery. Units are equipped to provide proper unloading to permit broad flexibility in meeting pressure conditions.

Below: Compressor cylinder side of above skid-mounted units. Floor line is flush with tops of skids resulting in conventional floor appearance and simplicity.

GMX's at Lone Star's Abilene Booster Station

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Secondly, and perhaps even more remarkable, is the unusual flexibility of this compressor set-up. The station is piped so that it can pump either east or west —necessitating compressors that would operate efficiently despite widely varying pressure conditions. These GMX's readily provided with the proper unloading facilities to permit such flexibility. And, with suction pressures running lower than anticipated, months on end, it's another example of how well GMX's can handle tough jobs.

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overall costs are dependent on local drilling conditions, availability and cost of handling fresh water, costs of surface disposal pits for salt water, and the complexity of allied surface installation. A good spread of costs for initial installations would be $0.75 to $2 per barrel; however, in areas where subsurface salt is not too deep, and after experience is gained it should be possible to produce a cavity of 60,000 bbl at a considerably lower figure. It should be understood that these are original costs. It is true that as the volume increases with rewashing carried on deliberately or during recovery operations that the cost per unit volume will decrease — and just as true that with time and stringer failure in the hole, workover costs will increase. One simply can't make a general statement as to how much it will cost a company to create an underground storage cavity.

Capacity

It should also be understood that there are some practical limitations to the maximum volumes to be created. Stringer systems do generally exist in the salt formation — these stringers do have a certain beam strength and if the span of that beam is increased by rewashing, a certain point will be reached where the stringer will collapse. This stringer collapse can crush the casing, or pinch off the tubing in the hole. The actual drilled hole (through the stringer) would naturally shift in relation to the initial drilling axis.

Stringer failure could conceivably result in a loss of the major portion of the storage cavity. At the least, it would involve pulling the tubing string and redrilling or washing through the collapsed stringer to reach total depth again and to recover the lower area for storage space.

System

The present LPG injection system is arranged in the following manner. (See Figs. 1 and 2.) The product is drawn from the storage area by a No. 1500 pipe line pump* with special packing to handle propane. The pump has a 2½-in. bore, 10-in. stroke, and is driven by a 40 hp electric motor. Product is pumped to the casing side at the well head. Salt water is displaced up the tubing and to the disposal pits. Injection pressures are not excessive, maximum ranging from 525 to 600 psi dependent on the difference in hydrostatic head between the light propane (0.508 sp gr.) and heavy salt water (1.363 sp gr). Pressures increase as the salt water head is increased during LPG displacement. (Bottom hole pumps at some installations have been run on the tubing to reduce LPG injection pressures by lowering salt water head.)

Recovery

The best recovery program is to inject salt water to the tubing with product returns from the casing. This will leave a relatively static interface between the salt water and LPG. Recovery of LPG through the tubing would necessitate a sweep of the entire volume across the dead salt water face to the tubing with a consequent danger of water pollution.

Some trouble can be encountered in recovery presumably due to configuration of the insoluble stringers in the cavity. Recovery rates drop off and it becomes necessary to stop-cock the well to allow entrapped LPG to work back to the free flow path. This will result in a recovery flowing schedule peculiar to each individual well.

Aside from the problem previously discussed, the limiting factors for recovery rates are volume vs. pressure characteristics of the pump, size of casing, tubing and flow lines.

Normal recovery operation is to return about 90 per cent of the LPG directly to car for shipment with the remaining 10 per cent (last to leave the hole) being sent to the dehydrator for processing to specification prior to shipment.

The original test injection was 55,000 gal of propane, which was recovered with no measurable loss but saturated with water vapor. Volumes injected for the year 1951 were recovered with a loss of approximately 7 per cent. A portion of this loss was actually returned in a gaseous state, but was not measured. Some initial loss was attributed to entrapped liquids due to irregularities in the cavity ceiling. Part of the initial loss

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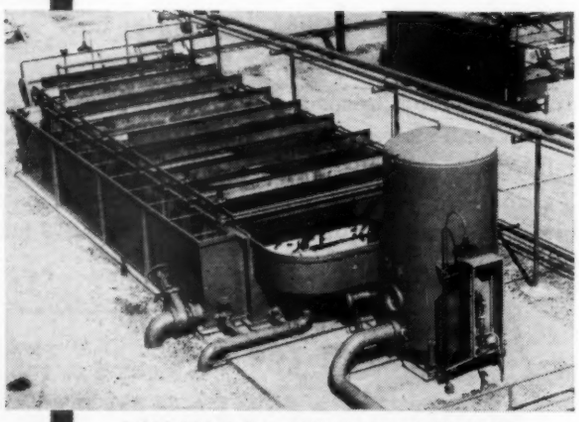
Refinery "C"	232.0	2.0
Oil-field brine "A"....	40.0	5.0
Oil-field brine "B" ..300 to 500		1.0 to 6.0



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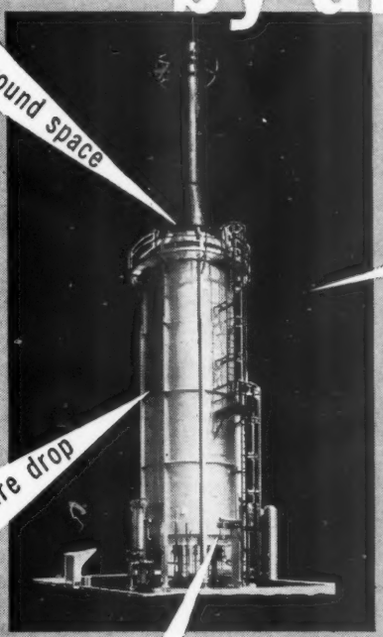

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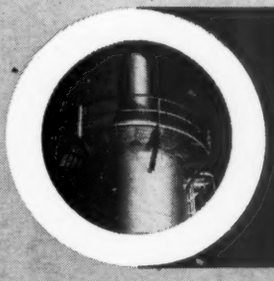

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would also occur in the dehydration system. It seems logical to presume that, with continued usage, dependent on handling procedure and condition of cavity, recovery losses should fall to less than 4 per cent.

Naturally the great advantage to be gained from low cost, high volume, underground storage will be a leveling process on the supply-demand curve. During the summer months a plant can operate on normal through flow, meet all orders and inject the excess to underground cavities. When the winter demand peaks arrive the excess underground volume would be used to fill demands over and above normal plant capacity.

Problems

Magnificent promises are always to be suspected; so, a word of caution. It is an unfortunate fact that the most favorable subsurface areas lie near the production centers rather than the consuming centers. Even though a demand-supply balance can be effected the necessity will still exist that the product must be moved at a greatly accelerated rate during the winter months. Rolling stock will remain relatively idle during the low demand period, depreciation and cost of this equipment however will remain constant. It, therefore, should be evident that consumer costs of product will not be greatly influenced by this revolutionary storage process. Furthermore, the actual development of the underground cavity is not without hazard. It is advisable to core the entire section of the proposed cavity area. If there exists an undetected continuous permeable stringer system, then the whole project will be a failure. Even though a careful core analysis has been made it is a good idea to keep an eye out for loss of returns during washing operations. The idea of overburden pressures vs injection pressures may seem far fetched; but at least one cavity has washed to the surface, presumably because of hydrafracing. Casing seats can be washed out that result in a juncture with a higher thief zone. Some areas have shallow fresh water sands that necessitate the construction of lined surface disposal pits to prevent salt pollutions. Cost of such pits would probably be greater than for the cavity itself. Caving of the insoluble stringers resulting in damage to the tubing string is a serious problem. This danger, of course, will still exist even though casing is set through the cavity area. It might become necessary to resort to shooting these stringers. Caving seems more likely to occur during LPG injections, rather than during the washing period. It could be the change in bouyancy as the heavy salt water is displaced with light LPG. In addition to the caving problem, the stringers are troublesome during recovery operations as previously discussed. Considerable trouble has been encountered in the tubing string due to whipping, vibration, and the leaks resulting therefrom. The new casing program described previously seems a step in the right direction in an attempt to minimize this latter source of trouble.

It is necessary to emphasize again that there is no substitute for experience, caution, thorough study of all pertinent data and careful supervision.

There exists today some 3,000,000 bbl of developed underground storage capacity.

Summary

Any organization that has a major need for extensive liquid storage capacity should recognize the following facts:

1. Any liquid, in which the natural salts are not soluble and which is not susceptible to change due to heat and pressure existing under cavity conditions, may be stored in underground reservoirs.

2. Suitable subsurface areas exist at the point of greatest production, in the vicinity of some industrial centers, and some of the heavily populated sections of the East.

3. The cost of underground storage (including surface installation peculiar to the LPG industry) should lie in the range of $0.50 to $2 per barrel of storage required.

4. The savings effected, dependent on product stored and market price at recovery date, should establish a payout in from one to five years.

5. The LPG industry in particular would benefit in its ability to meet year around demands with a consequent increase in public confidence. * * *

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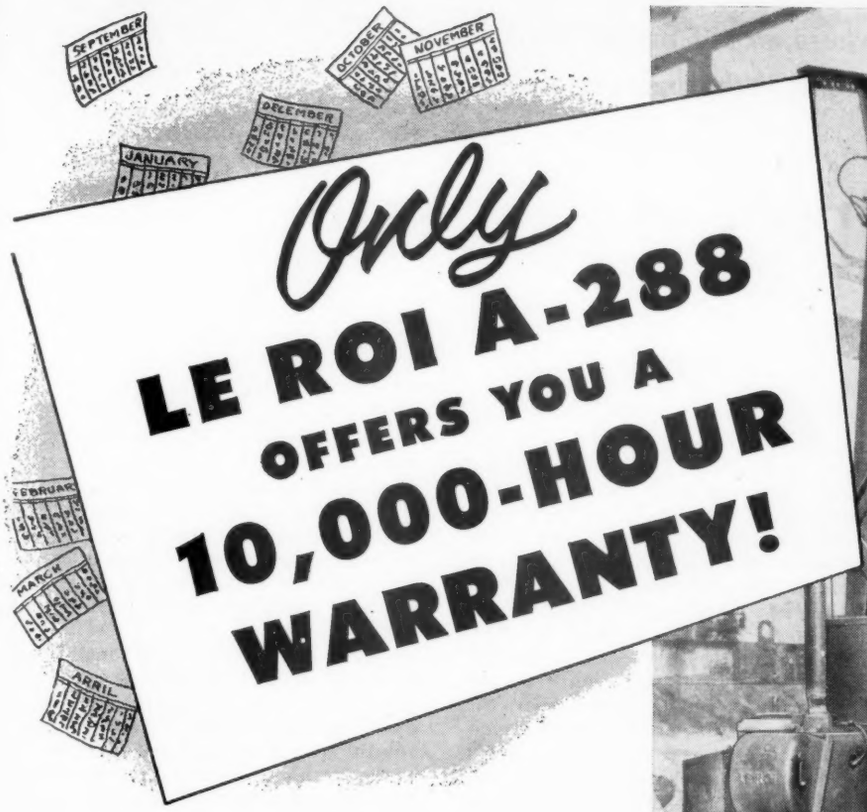

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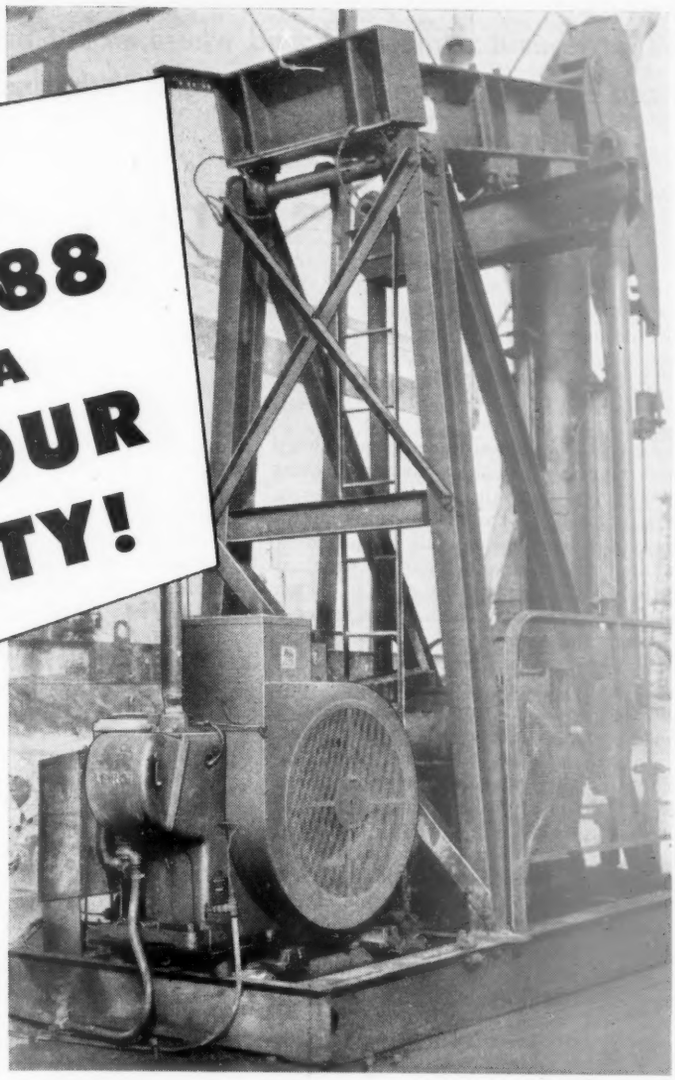

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P-117

What does it come from and where was it made? Many problems would be met or changed if the industry knew

The Origin of Petroleum†

F. MORTON*

DESPITE the importance of petroleum and the many investigations and theories concerning its origin very little is known with certainty. This is because petroleum is a fluid and capable of movement so that the reservoir rocks in which it is found may not be the rock in which the oil was formed. The uncertainty concerning the source rocks of petroleum has made the study of the origin of petroleum difficult and at the same time offered scope for innumerable theories based on the lack of positive evidence.

In recent years there has been considerable research into the constitution of petroleum and although a great deal is now known concerning the nature of the hydrocarbons which constitute the gasoline and kerosine fractions of several petroleums, this has to some extent complicated the picture for it now appears that petroleum may vary in its composition over very wide ranges of physical and chemical character.

Historical Theories

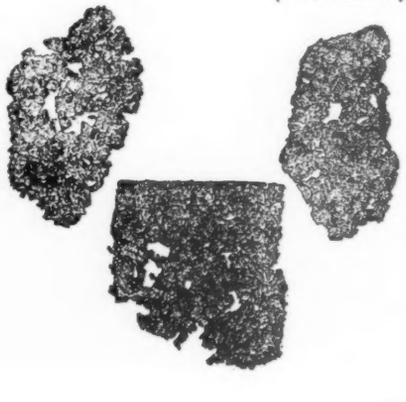
Although the majority of the theories advanced during the past 50 years to account for the origin of petroleum are now of historic interest only and have little bearing on the modern theories on this subject, a brief historical survey is of interest as showing the necessity of a combined approach of the respective sciences to this particularly difficult problem.

Petroleum and natural gas occur in sedimentary beds. There are several instances of commercial production from igneous rocks but in all cases the oil is believed to have originated in adjacent sedimentary rocks and to have migrated to the igneous rock which has acted merely as a reservoir. Petroleum is normally found in sands and sandstones associated with clays or shales, or in porous limestones and dolomites, and occupies the space between the grains of sand or fills the pores and cracks in the limestone. The pore space may constitute from 1 to 30 per cent of the rock. Typical sections of an oil-bearing limestone are shown in Fig. 1. Usually the oil occurs in the anticlinal fold of the structure, but it is also found in inclined structures sealed at the upper end by any of several means. Usually the gas, oil, and water separate by gravity into three layers, but not all commercial pools have gas caps or active water drives.

Typical modes of occurrence of oil are shown in Figs. 2 and 3. Fig. 3 represents a cross-section through a salt dome. Here three types of oil reservoirs are shown, (a) the typical anticlinal accumulation, (b) the sealed or pinched out stratigraphical trap, and (c) the fault trap. In each case, however, the oil-bearing strata must have an impermeable cover, the cap rock, to prevent the escape of oil. When the oil-bearing formation has been drilled and the well is producing, the oil flows to the well casing by pressure differences caused by the gas in solution being released (solution gas drive), the expansion of the high pressure gas above the oil level (gas cap drive) or the sweeping in of the edge water, which invades the oil-bearing strata as the oil is removed (active water drive). When the gas drive begins to loose its pressure differential the well may be further produced by pumping.

The first theories advanced to account for the formation of petroleum were inorganic. Berthelot in 1866 suggested that mineral oils were formed by the action of water on metallic carbides such as calcium and iron carbides. In addition to the possible formation of oils by polymerization of acetylene Berthelot had been able to demonstrate that iron carbide when treated with water did give rise to hydrocarbons not unlike those present in crude petroleum. The presence of iron carbide in meteorites was considered by Berthelot to be evidence in support of his theory that such carbides would be present in the earth. Mendeleef, about the same time, showed that the action of carbon dioxide and water upon the alkali metals sodium and potassium gave small quantities of hydrocarbons and therefore suggested this as a possible means of formation of petroleum.

FIG. 1. Enlarged sections of Trenton limestone showing nature of pores.
(After Orton)



Neither carbides nor alkali metals are known to exist in the earth's crust, but if they do exist they can only do so at the high temperatures associated with volcanic phenomena. As the greater part of the earth's oilfields are not associated with such phenomena and indeed, some of the largest oilfields are very far removed from any center of igneous activity, the theories were never seriously accepted by geologists and indeed Hofer in his classic examination of these views had reduced them to absurdity. Nevertheless because of the reputations of the authors the theories were long considered tenable by chemists.

The possibility that petroleum was derived from organic material, such as the remains of plants and animals, buried in the sea has always been favoured by geologists, possibly in the first case because oilfield waters are almost always brine — although of somewhat different composition from the present sea water, but the mechanism by which such deposits could be converted into petroleum has been the subject of much speculation and dispute. The theory that petroleum was formed by the distillation of organic matter was first suggested by Newberry and Orton. Later, Day and subsequently Engler obtained paraffin hydrocarbons by the laboratory distillation of vegetable oils and fish oils, etc., and the theory that petroleum was formed from animal remains by such distillation process was developed by Engler and supported by Hofer.

It is again apparent, from the many geological surveys published during the period that the Engler-Hofer theory held sway, that geologists were never very happy about this theory simply because it required the application of a temperature not normally met in oil reservoirs. To produce oil by the distillation of the calcium salt of a fatty acid, or by distillation of organic sediments, requires a temperature above 350 C and probably nearer 450 C. The normal increment of heat in the earth's crust is about 1 C for every 100 ft so that even at a depth of two miles the temperature of the sedi-

†Presented before the Stanlow Branch, Institute of Petroleum, and first published in the Institute of Petroleum Review, London, May and June, 1952.

*Vice President, Department of Chemical Engineering, University of Birmingham, England.

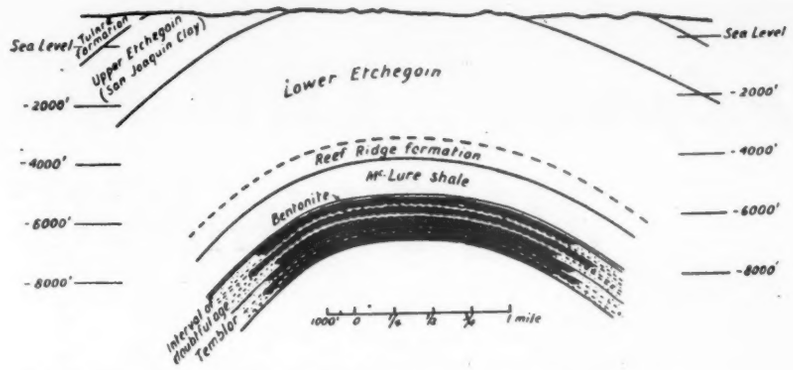


FIG. 2. Ideal cross section through the Kettleman Hills north dome.

ment would only be raised by 100 C. Although several other objections to the Engler theory have been made the temperature required for the distillation led to its being finally rejected. Even if the theory were tenable on geological grounds, the presence of certain porphyrin derivatives known to decompose at temperatures in excess of 200 C and the presence of optically active constituents indicate the low temperature origin of petroleum.

The possible similarity between the origin of coal and petroleum has naturally attracted attention and several investigators, notably David White (1916) and Cunningham Craig (1912) have suggested that oil and coal are derived from similar source materials. The association of certain oil-producing strata with lignitic beds in certain parts of Europe and America led White to compare the geological occurrence of coal and oil and to suggest that both were derived from similar source materials, but that subsequent effects of heat and pressure resulted in certain cases in coal and in others in the formation of oil. The fact that coal has been formed in the main from vegetable matter deposited in fresh water, whereas the bulk of the oilfields are associated with salt water and hence by inference with marine deposition, made White's views unacceptable to many geologists. Although the theory was given very serious consideration it is no longer considered adequate.

Organic Material

Out of the various discussions and theories of the period 1900 to 1930 there arose a body of evidence to suggest that petroleum was formed by the decomposition of plant and animal remains that had been buried with sedimentary rocks, and that the original deposition of the organic material had taken place under marine or brackish water conditions.

The means by which the organic matter was converted into petroleum was unknown, although the general opinion appears to have favoured the action of some kind of anaerobic bacteria. Anaerobic conditions were believed essential if any sizable accumulation of organic debris on the sea floor was to escape the normal scavenging of deep sea life. The type of sedimentation, the amount of organic material and the time and depth of burial needed to ensure the formation of petroleum were subjects of general speculation, but no single unified theory had been advanced until the publication of Krecji Graf of his studies of the relationship between crude oil and stratigraphy in the Roumanian oilfields. Krecji Graf showed that in Roumania the oils in the younger strata were normally naphthenic in character, but as the depth of the deposit and its geological age increased the oils became increasingly paraffinic, and lighter. He therefore suggested that petroleum was formed from richly organic source beds, such as the type now met with in the Black Sea, containing above 30 per cent of organic matter and that temperatures and pressures compatible with a minimum depth of burial of 4000 metres were necessary to convert this material into a "proto-petroleum." The proto-petroleum was believed to be paraffinic but as it migrated upwards it was changed by various reactions into petroleum of increasingly naphthenic character.

This theory attracted considerable attention. Many petroleum geologists accepted the theory completely, some accepted the general theory of deep burial, but believed the proto-petroleum should be asphaltic in character rather than paraffinic, while others considered the occurrence of the richly organic deposits of the euxinic (or sapropelletic) type to be so rare as to preclude their being the normal type of deposit leading to petroleum formation. There was also a belief among many geologists that deep burial was not necessary but that on the contrary petroleum could be formed from shallow depth deposits and this in turn necessitated the assumption of a relatively rapid rate of formation of petroleum at low pressures and moderate temperatures.

D. C. Barton made an extensive study of the relationship between crude oil character and stratigraphy in the Gulf Coast oilfields of the U.S.A. using the gravity interval method of plotting the U.S. Bureau of Mines distillation analysis of crude oils and concluded that the nature of an oil was related to the depth of burial, but he did not agree that the younger oils were formed from the older and deeper oils. He considered that similarities in oils of different areas or of differing stratigraphical horizons in the same area were an indication of similar source materials and similar histories. Hans Hlauschek extended Krecji Graf's studies to include the analysis (in terms of paraffinic and naphthenic oils) of oils from many parts of the world in order to examine the relative merits of the two opposing theories. It is interesting at this stage to repeat Hlauschek's point by point analysis of the fundamental inferences of each theory.

Deep Burial Theory

The Deep Burial Theory, based upon the view that petroleum is formed at great depth and moderately high temperatures, requires the following assumptions:

1. That the formation of petroleum is an extraordinary — or only rarely occurring — process.
2. The only source rocks that can be considered are certain rare sediments (sapropelletic) which are distinguished in many ways from the more common sediments and particularly by an extraordinary high content of organic matter.
3. The conversion of the source material into petroleum is only possible at temperatures above 150 C which by ordinary geothermal relationships requires a depth of not less than 4000 meters.
4. The so-formed petroleum consists essentially of hydrocarbons of the paraffin series.
5. The petroleum migrates upwards to zones of lower pressure.
6. The migrating oil penetrates into suitable porous rocks and forms in these reservoir rocks secondary deposits.
8. In the region of normal tempera-

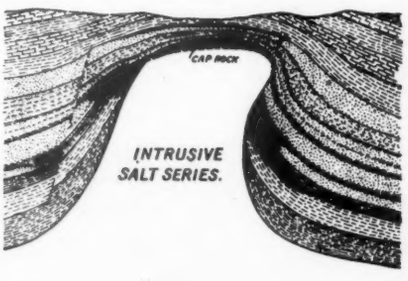


FIG. 3. Diagrammatic cross-section through a salt dome. The three sites of oil accumulation associated with salt domes are illustrated. In addition there is trapping due to uncomfortable conditions, and the highly disturbed nature of the structure near the flanks of the salt intrusion leads to considerable faulting, and such faulting produces further local oil accumulation.

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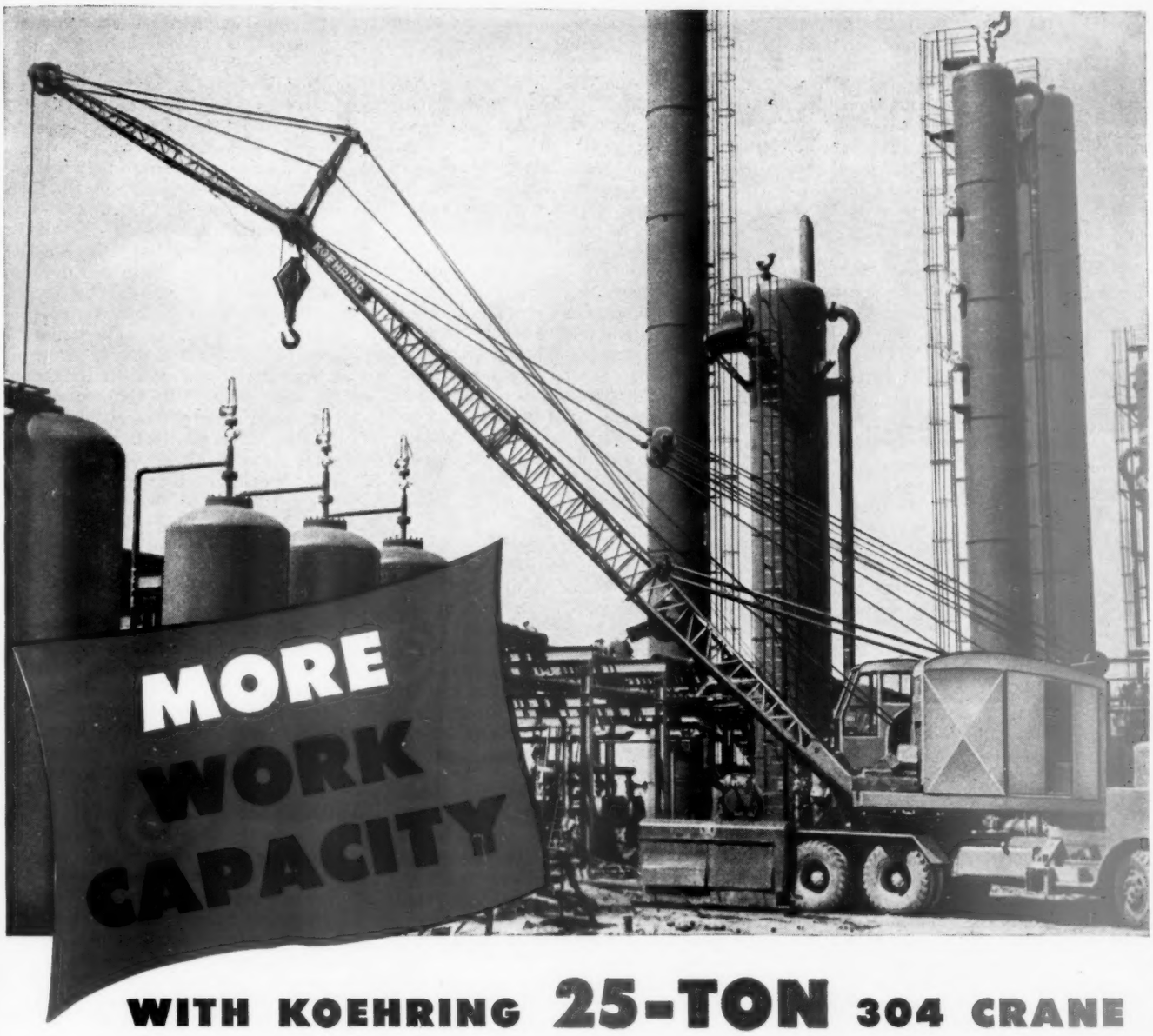

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ture rises (1 C and 33m) and normal layering (with due allowance for faulting, slipping, and erosion, etc.) all sediments and deposits of less than 4000 meters depth are of secondary nature.

9. The chemical variety of such oils is essentially due to physical and chemical influences during the geological history. Differences in source material are not considered of importance since the "proto-petroleum" was originally paraffinic.

10. The naphthenic oils have been formed from the paraffinic oils during the migration or by surface action (catalytic).

Shallow Depth Theory

The Shallow Depth of Burial Theory, in direct contrast, postulates the following points:

1. The formation of petroleum is a common process which under certain definite conditions can be repeated in the same place (i. e. in several overlying layers and formations).

2. All marine and brackish water clays and marls are considered possible source rocks. Under certain circumstances fine sands, dolomites and chalk may be source rocks particularly, if they have a higher content of organic matter than the average. An organic content of 4-8 per cent, in contrast with the average organic content of 1.5 per cent would apparently lead to the formation of significant oil strata.

3. The conversion of the source material to petroleum occurs at depths not greater than 1500 meters and at temperatures considerably below 100 C.

4. The chemical character of the oil is dependent upon the nature of the source material and upon the chemical, physical, and biological relationships during and immediately after the transformation.

5. Petroleum has a general tendency to migrate upwards, but the migration of large quantities of petroleum across considerable strata seldom occurs and is not the general rule.

6. Any migration over considerable distance is usually by open clefts.

7. The migrating oil enters into suitable reservoir rocks and forms in these reservoirs deposits which are designated as primary if the source rock is immediately neighbouring and as secondary if a large stratigraphical distance lies between them.

8. If several oil deposits occur one above the other then it is possible — indeed probable — that one or more are primary in the above sense.

9. The physical characteristics of the oil can be altered during the geological history within certain limits. The chemical character is less likely to be altered and differences in chemical nature of oils are due in the main to differences in source material and differences in sedimentary environment.

10. The preponderance of paraffins (paraffin base), or alternatively, of naphthene hydrocarbons (naphthenic base) is an unalterable property and is therefore a suitable criterion for identification. Paraffins and napthenes cannot as a rule be derived one from the other and are derived independently of each other.

Hlauschek took the view that the conversion of paraffinic hydrocarbons into naphthenes was a necessary constituent of the deep burial theory and therefore a logical basis upon which to attempt a proof or otherwise of the theory. In support of the deep burial theory was the fact that in petroliferous provinces containing several oil-producing horizons the shallower oils were normally more naphthenic than the deeper oils, although exceptions were known. Despite this Hlauschek did not consider that under normal conditions paraffinic oils could be converted to naphthenic oils. Laboratory work has since shown that the conversion of paraffin to aromatic hydrocarbons and thence by hydrogeneration to derivatives of cyclohexane is possible but the conditions are such as to preclude the reaction being responsible for the change of oils.

Chemical Evidence

The controversy concerning these two theories resulted in a renewed attack on the problem. In the laboratory, Berl obtained petroleum-like mixtures from the treatment of cellulose materials in the presence of aqueous alkalis and he supported the deep burial theory, but believed the proto-petroleum to be asphaltic in character — a view supported by Brooks. Strangely enough the geologists were not particularly interested in the chemical nature of the evidence. The question of whether or not paraffins could, or could not, be converted to naphthenes was of little importance as compared with the more important problems of source material, sedimentary conditions, environment, and migration. Reference to many of the geological writings, particularly to the replies to the questionnaire of Parker and Van Tuyl on the "Time of Origin and Accumulation of Petroleum" suggests that many geologists believed that, since conditions had existed in which organic material had been converted into a variety of petroleums, there was reason to assume that other conditions might have existed capable of transforming one type of petroleum into another. In particular migration of oil across formations containing certain clays, etc., could, presumably by catalytic action, bring about reactions of polymerization or depolymerization and by adsorption and other means the relative quantities of paraffins, naphthenes, and aromatic hydrocarbons could be altered to produce the types of oils found in various provinces. Reactions such as the action of sulfur, hydrogeneration by methane, the effect of bombardment by a particles and many others, have been suggested to account for the alteration of oils either during migration of during the period in the reservoir rock. More recently the catalytic action of various earths which may bring out rearrangement of hydrocarbons by carbonium-ion mechanisms have been suggested as a means whereby oils can be converted from one type into another. Thermodynamic studies (1933) have indicated that "cracking" reactions are unlikely to have been possible at the low temperatures postulated (not above 150 C) within geological time unless assisted materially by catalytic, or other effects.

All these various theories the geologist has considered as useful contributions to the subject and has attempted to fit them into the framework of the known geological facts. Only one thing is asked of the physicist or chemist who proposes a theoretical path from a known starting material (cellulose, sterols, proteins, etc.) to a petroleum-like mixture of compounds. That is that the steps in his reaction mechanism shall comply with these facts: that the source material was laid down in marine or brackish water sediments, that the petroleum has almost certainly been in direct contact with brine or water wet clays and sands throughout its history, that its temperature has probably never exceeded 150 C (as shown by the presence of chlorophyl porphyrins and by the retention of optical activity), and that petroleum as it occurs in the reservoir does not contain any olefins. Mechanisms that postulate decarboxylation of organic acids by heat, or the catalytic effect of anhydrous hydrofluoric acid or other agents such as aluminum chloride, or which postulate reactions based on olefinic intermediates are not acceptable.

Although the two opposing theories of shallow depth of burial and deep burial attracted chemists and physicists to investigate the chemical changes involved, the geological attack on the problem was even more intense. This followed three main lines of attack. The first was an intensive search among all sedimentary rocks near to a known oilfield for evidence of deposits of the euxinic, or black shale type. The second was an investigation of the organic content of modern deposits and a study of the microbiology and the organic content of the offshore ocean depths, and the third a renewed study of the relationship between crude oil composition and stratigraphy. With these three main studies were allied the day-to-day field observations of exploitation and exploration geologists whose opinions and the supporting data have been collected and edited by Parker and Van Tuyl.

Study of Sedimentary Rocks

Parker D. Trask (director of the American Petroleum Institute Research Project on Source Beds) has examined the organic content of several thousand samples of ancient sediments ranging in age from Cambrian to Pliocene. The average organic content of these sediments is of the order of 1.5 per cent. Very few sediments in existing oilfields contain less than 0.5 per cent or more than 5 per cent of organic matter. The average organic content of recent sediments is about 2.5 per cent by wt. This varies considerably with the environment. In near shore marine sediments it varies from 1 to 7 per cent, being large in areas characterized by plentiful plankton. In some fresh water lakes it

may be as high as 40 per cent, and in some deposits in the Black Sea it is 35 per cent. In typical ocean sediments far from land it is seldom in excess of 1 per cent.

Krecji Graf's view that a sediment must be very rich in organic matter in order to be a source bed was based on the belief that an excess of petroleum must be formed, before the oil can migrate, over and above that needed to saturate the clay particles that the oil might meet in the process of migration. As the average difference of organic matter between modern and ancient sediments indicates a loss with age of approximately 40 per cent of the organic content, Trask does not consider that any of the ancient sediments examined can have originally contained much more than 10 per cent of organic matter. This is far below that postulated for "euxinic" or black shales. Nevertheless Trask believes that an organic content of from 5 to 10 per cent is probably necessary before a sediment could give rise to commercial accumulation of oil. Other factors investigated in this survey include the nitrogen and oxygen content of the organic material. These figures indicate a lower oxygen content than would normally be associated with natural fats, or at least suggest that the sediments associated with petroleum deposits have contained organic matter low in oxygen and not of a fatty nature.

Oceanographic Studies

The oceanographic studies of Zobell and his colleagues have shown that bacterial activity in marine deposits decreases very rapidly from the surface downwards. This is in agreement with the view of Trask who suggests that the organic matter originally deposited with the sediment would be used up by bacterial oxidation (to CO_2) unless the available oxygen is insufficient to support such an action. In Zobell's work it has been shown that the surface of the sediment can support some aerobic bacteria, but with increasing depth the quantity of bacteria increases rapidly.

Zobell and his co-workers have devoted much time to the study of bacteria in relation to the destruction of and formation of petroleum. It was, of course, known that certain bacteria, yeasts, and moulds were capable of utilizing hydrocarbons such as petroleum, vaseline, naphthenes, phenols, cresols, etc. Methods for the disposal of phenolic effluents have been based on such processes. Lipman and Greenberg obtained a coccus, or coccobacillus from petroleum from a depth of 8700 ft which decomposed petroleum completely to carbon dioxide. The anaerobic decomposition of organic material by bacteria normally produces methane with minor quantities of high hydrocarbons. Neave and Russel, however, have reported up to 12 per cent of ethane in the gas produced by anaerobic bacteria in sewage, and Rawn and his co-workers have reported the presence of ethane, propane, pentane, and butadiene in these gases. The amount of the higher hydrocarbons is, however, small and Zobell, Grant, and Hass give the following analysis of gas from the anaerobic decomposition of sewage sludge:

	Per Cent
Methane	67
Ethane	0.04
Propane	0.01
Butane	0.01
Pentane and higher	0.07

Other bacteria have been investigated that are capable of producing hydrocarbons from fatty acids. The first type to be studied was a sulphate-reducing bacteria that when grown in sea water enriched with fatty acids, at a temperature of 78 F, produced appreciable amounts of oil-like ether-soluble, non-saponifiable matter. From *n*-caproic acid, extracts, identified tentatively as a mixture of *n*-paraffins from $C_{15}H_{32}$ to $C_{25}H_{52}$, and wax were obtained. Other fatty acids gave similar results. Other bacteria have since been discovered that are capable of decomposing, or fermenting, organic matter with the production of hydrocarbons and hydrogen. The activity of these bacteria is controlled by the Redox potential and *p*H of the marine sludge and maximum production of hydrogen is obtained within very narrow limits of both criteria.

Zobell's "Marine Microbiology" surveys the field of these researches and has done much to strengthen the view that petroleum has been formed by bacterial action within sediments containing organic matter, and that the conditions of sedimentation (*p*H of the water, Redox potential, salinity, etc.) may well have exerted a marked influence on the course of the bacterial decomposition.

The view that much of the organic matter from which petroleum has been formed may have been bacterial protoplasm has been advanced with the suggestion that the methane produced by anaerobic decomposition might interact with the partially reduced organic matter and so lead to the formation of petroleum. There is, however, little experimental evidence in support of these views.

Composition Related to Stratigraphy

The relationships between crude oil composition and stratigraphy have been intensively studied in two main areas. The pioneer work of D. C. Barton in the Gulf Coast area and the extensive surveys of Krecji Graf and Hlauschek in Europe were based on certain physical properties of the various fractions of the crude oils. Hlauschek's "depth rule" and "age rule" for instance relate to bulk properties of the crude oils, and differences in, for instance, specific gravity of crude oils with depth may not necessarily be results of the change in type of crude oil, but may be due to changes in the relative amounts of light fractions in the crude, caused possibly by physical effects in the reservoir rather than by differences in the origin of the oil. Obviously a much more detailed analysis of the crude oils is necessary in order to establish differences in the chemical nature of oils independent of physical characteristics.

The Research Committee of the Tulsa Geological Society have accordingly undertaken an extensive survey of the crude oils of Northeast Oklahoma and Southwest Kansas. Oils were analyzed by the U. S. Bureau of Mines Hempel distillation method, and characterized by their correlation index curves. Several hundred samples of crude oils were examined ranging from the upper part of the Arbuckle limestone of Ordovician age to sands of Pennsylvania age. The oils from pools associated with the unconformity at the top of the Arbuckle limestone and at the top of the Mississippi lime were extremely variable, but the oils from the Burbank sand, distributed through an area 150 miles long and 1 to 35 miles wide were all of one class. This sand is an old shore line and is confined to a very narrow stratigraphical horizon; the lithology is similar throughout. The similarity of oils within this sand shows that the depth of burial and degree of folding (which is severe in some areas) have had no effect upon the character of the oil and the authors suggest that the controlling factor in the character of the oil has been the original environmental conditions of deposition of the source rock. This would be similar or identical for the Burbank sands but would vary considerably in rocks connected with an extensive unconformity. In the case of lenticular sands associated with the unconformities it is suggested that the oil has originated within the sand, or within the immediately surrounding clay bodies.

The degree of fractionation involved in the U. S. Bureau of Mines Hempel distillation is not very high and for this reason the use of the correlation index alone for distinguishing between different oils is not entirely satisfactory. The Tulsa Geological Research Committee has, however, included in the analytical details the sulphur content and other properties of the crude oils. This enables a degree of comparison to be made with the many thousands of analyses by this method published by the U. S. Bureau of Mines. There can be little doubt that the oils throughout the entire Burbank sand are so similar in character that the conclusion that the sand contains only one type of oil is justified.

Comparison of the oil in the lenticular sandstones above the unconformities is however less simple, but again the view of the authors that the variety of oils found is indicative of different source environment or material is supported by the analysis. There does not appear to be any relationship between the distribution of oil types and structural features such as might be expected had the oils originated in a common source rock removed from the immediate vicinity. This is, however, not entirely proved by the published details.

An intensive survey of the Miocene oils of southwest Trinidad has been undertaken by the research division of Trinidad Leaseholds Ltd., with the object of supplying evidence concerning the origin of these oils. The method of

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analysis used enabled a detailed estimate to be made of the individual hydrocarbon components in the gasoline fraction, and certain properties of the residues, such as asphaltene, sulfur, and nitrogen content permitted correlations in the basis of the crude oil. Three distinct areas have been examined and reported, the crude oils of the Forest Sands of the Bernstein field, the oils of the Forest, Upper, and Middle Cruse sands of Morne Diablo-Quinan and the oils of the Forest, Middle, and Lower Cruse sands of the Forest Reserve field.

The wells in these areas produce from a number of sands, and as the sands are in many cases lenticular the problem of correlation has proved extremely difficult. In the Morne Diablo-Quinan field, where the Middle Cruse sands are continuous and approximate to sheet sands, examination of the analysis of various groups of oils produced from one, two, three, four, or five sands permitted the assignment of a discrete oil type to each sand. In the Bernstein field, examination of the oils of the Forest sands indicated a movement of oil through the field and this was illustrated by contour maps of various chemical parameters on the geological map of the field. A particular movement of oil was observed, apparently originating along one side of a major fault and spread into the four Forest sands.

New Migration Theories

Subsequent investigation showed the distribution of oil types to have evened out, suggesting that the migration observed was a temporary, production induced, migration. The complete investigation of the oils of the Forest Reserve field — Forest sands, Upper-Middle, and Lower Cruse sands occupied a period of four years and involved the analysis of over 1000 individual crude oils. Obviously the publication of these analytical data in a complete form in a journal was impossible, but a summary of the results* was presented to the World Petroleum Congress, The Hague, 1951. This shows that each individual sand of the many sand zones examined contained a discrete oil, the type of oil varying slightly from naphthenic oils in the Forest and Upper Cruse sands, to a naphthene-paraffinic type in the Middle Cruse sands and to naphthenic oils in the Lower Cruse sand.

No regional variation related to tectonic features could be observed. The older theories that the oils of the Miocene sands had migrated from some deeper source rock, the migration proceeding via the Los Bajos fault and other faults, could not be supported and it was suggested that the oils had been formed in the underlying clays and marls which, having extensive development into the synclinal basin, could have contained sufficient organic matter to serve as source material. The evidence obtained in the Morne Diablo-Quinan field supported this view. The minor variations in oil type observed were believed to be due to changes in source material and depositional environment throughout the Miocene period.

It is significant that both the Tulsa Geological Society survey and the Trinidad Leaseholds surveys—the only surveys on such extensive and intensive bases that have been made on any multizonal petroliferous province, should state that the evidence in each case indicated an indigenous origin of the variety of oils in each area. In both cases the possibility of migration from a deeper source rock had been postulated by earlier workers, but in each case the regional variation in oil types precluded the acceptance of any such migration. It may well be that other investigations in other areas will establish beyond doubt vertical migration from depth, and it is obviously desirable that all areas in which, on geological grounds, migration over some distance is a possibility should be submitted to exhaustive analysis. In the meantime the evidence of these surveys supports the view that oil is formed by shallow depth of burial and moves to the adjacent reservoir rocks shortly thereafter—and that variations in oil type are due to variations in source material and environment.

The exact mechanism by which the source material is converted to petroleum is, however, still in doubt. Treibs has suggested a sequence of events, first a micro-biological process, anaerobic in character, to convert fats, proteins, cellulose, sterold, etc., into a "proto-petroleum" of indeterminate character, followed by catalytic processes involving rearrangement, isomerization, polymerization, cracking, and cyclization. By what catalysts these are brought about is not certain, but Treibs suggests, as does Brooks, that clay minerals, particularly Bentonites, Montmorrillonite, etc., are very active catalysts and that in the finely divided state with which they would be associated with the organic matter in the early sediments they would be even more active. Following earlier work of Lind on the action of α- radiation on organic matter, Sheppard and his colleagues have investigated the dehydrogenation and decarboxylation of fatty acids on bambardment with α-particles as part of the API research project No. 43 C. The investigation of the organic content and radioactivity of a large number of sedimentary rocks by Russell has shown a marked relationship between certain types of organic matter and radioactivity. The significance of these results in relation to the genesis of petroleum is still under discussion. The most satisfactory approach to the problem would appear to lie in the work of Zobell. An intensive search for micro-organisms capable of converting the variety of source materials suggested by Triebs into hydrocarbons, or the intermediates postulated, is now necessary. Further studies of the relationship between crude oil composition and stratigraphy throughout oilfields of the world is also much to be desired. In the present state of knowledge one fact is worth more than a multitude of of theories. * * *

*Proc. Third World Petrol Congr., 1951, 1, 345-55.

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Petroleum Profile

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president of
Big Chief Drilling Company and
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LOOKING at tiny "bugs" through a microscope in a World War I military laboratory probably ruined the makings of an outstanding chemist. At least, that task caused a yearning in the breast of a young "shave tail' 'in the Sanitary Corps to get into the sunshine of the wide open spaces of the southwest.

For, when he pulled off his uniform in 1919, William Thomas Payne returned to Oklahoma City in search of a job at a time when good jobs were scarce. He became an oil scout for the North American Oil Company at Cement, Oklahoma.

That tells the story of how "Bill" Payne got into the oil business, a business that all he knew about was what he read in the newspapers. Born at Tecumseh, Nebraska, he attended school in Oklahoma and received his BS degree in chemistry at Oklahoma A & M College in 1915.

Intent upon getting a doctorate, he attended Massachusetts State College, but soon went to work in the department of health at Detroit because of a scarcity of biologists. In 1918 he was given a commission in the Sanitary Corps and assigned to the microscope brigade in one hospital after another.

In 1921 he went to work for W. H. Helmerich, Tulsa producer-contractor and in 1925, the firm of Helmerich & Payne, Inc., was organized with Payne as vice president. He was representative for the company in the Oklahoma City boom development, and one day took on more deals than the company had rigs for. One of the deals was for a well on a short-term lease. Additional rigs could not be leased, but a supply house was willing to sell Payne a rig.

Payne got the rig in April, 1936; the location proved an extension to the field, so in December the Big Chief Drilling Company was organized, when Payne sold his interest in the Tulsa firm.

The industry well remembers what happened about that time, and Payne often has remarked: "If the contractors and some producers had sold everything they had at that time, we'd all have been better off — I guess." But Payne didn't sell; today his rigs are strung over Oklahoma and West Texas, and he has oil and gas production in several states.

It was during World War II that Payne's "other people's interests" was taking more and more of his time. He organized Payne Petroleum Company, and brought Jack H. Abernathy, an up-and-coming young petroleum engineer, into the firm.

The other side of Bill's life deals with his activities for his community, state, and industry, or that part of his life which, he says, results "from other people being nice to me and helping me when I needed help."

In the early days when Bill made a little extra money it leaked out that he had made a modest donation to a group of women church workers. It was not long until he was identified publicly with the group which built the Westminster Presbyterian Church, one of the finest and largest in Oklahoma.

That led him into the activities of the YWCA, YMCA, the Boy Scouts of America (he's a member of the Last Frontier Council) and other organized welfare and youth movements.

From a "contributing member" of the Oklahoma City Chamber of Commerce, he moved into the directorate, headed special committees and organized the oil and gas division.

The chamber work threw him into the affairs of the State Chamber of Commerce, and the Oklahoma Expenditures Council, and he helped work out the Oil Industry Information Committee's program in Oklahoma.

All of which fits him for a page in the history of the Mid-Continent Oil and Gas Association. He began there, too, as a contributing member, served on committees, headed the Kansas-Oklahoma division, and now is on his second term as president of the general association.

He has served the Independent Petroleum Association of America in various positions, and is a director of the American Petroleum Institute. He is a member of the National Petroleum Council and a director of the National Association of Manufacturers.

When the American Association of Oilwell Drilling Contractors was organized during the war days, Payne was among the charter members.

His interest in research led to other fields; he is a director of the Southwest Research Institute, has been identified with the Midwest Research Institute; he was one of the prime movers in launching the Oklahoma Medical Research Foundation, and is a contributor to possibly a half-dozen other institutions or groups.

In the oil industry there are many public spirited men who know that progress has to be propelled. Bill Payne knows it and does more than his share of pushing.

Although he declares each year he will step down from civic and industry affairs, there is always some one who will ask: "Can't Bill Payne handle that job?" — and Bill always is drafted to do the job, without publicity or fanfare.

What Is the Limit to Deep Oil Operations?

Several queries confront the operator. These are: How deep is deep? How deep can a drill go? What is the maximum depth from which fluid can be lifted artificially? How deep is the lowest productive pay? All these resolve into a generalized question: What is the limit to deep oil operations?

About a decade ago 10,000 ft was the limiting depth of the drill, whereas today it is 22,000 ft. This means that deep drilling has advanced progressively into the unknown at an average of 1200 ft per year. Will 1963, that is 10 years hence, reveal a well with a total depth of 34,000 ft?

Drilling to 15,000 ft does not present formidable problems now; it is in many cases a routine procedure. Problems are encountered, of course, but they are surmounted. Today real deep drilling is conducted between 15,000 ft to 22,000 ft. Below 22,000 ft the operation momentarily is speculative. In the near future if the present trend continues, the target will be 30,000 ft at least.

For clarification deep drilling could be described accordingly. (a) Deep, 8000 to 10,000 ft. (b) Quite deep, 10,000 to 15,000 ft. (c) Very deep, below 15,000 ft.

Many factors are involved when drilling deep. Some of the more important considerations are: 1. Economics. 2. Surface equipment. 3. Down the hole equipment. 4. Subsurface temperature and pressure. 5. Drilling fluid. 6. Deviation. 7. Services.

To drill at depth is a very expensive operation—a deep test in Venezuela cost $3,500,000 — and in addition a dry hole may result. The economical factor is of paramount importance and costs must be considered for every item.

Deep drilling necessitates additional loads, and surface equipment will be subjected to increased stresses and strains. The mechanical features of the equipment must be engineered. A drill string of 20,000 ft—it is incredible. The avoidance of a twist-off or back-off is desired, but fishing operations cannot be overlooked.

At depth, temperature and pressure may reach serious proportions, and drilling fluid problems are accentuated. A straight hole is a prerequisite in normal drilling and to restrict deviation at depth requires considerable and constant control. Logging surveys, cementing, acidizing, formation fracing, formation testing, and perforating are services that must continue to facilitate production.

Deep production operations are concerned with pay zones below 5000 ft. Two phases exist, which are namely, flowing conditions and artificial lift. Artificial lift is sub-divided into the following categories; pumping by sucker rod; pumping by a hydraulic system; a submergible electric centrifugal pump, and gas lift. (All except the first are rodless methods.)

The selection of a suitable lifting method needs close investigation. Incorporated in the mechanics of lifting fluid from excessive depth are strength of materials, frictional losses, efficiency, and economics. Thought must be given to the interferences of paraffin accumulation and corrosion that often prevail in producing operations. The application of a long stroke pumping unit, the hydraulic method, and a piston type gas lift tool are being studied for lifting fluid from 15,000 ft, and probably 20,000 ft.

A word of praise—indeed it is appropriate to say words of praise—is due to the equipment manufacturer and service company for their efforts and farsightedness. Have they failed to have the equipment for each successive deeper operation? No, they have not, neither will they fail to have such ready for 30,000 ft wells or deeper. They are spending considerable time and money perfecting equipment, methods, and techniques so that the oil industry can operate at an increased depth.

Regarding deep operations, the pessimist may think that geologically, 20,000 ft is outside the sphere of productive horizons. But the optimist, naturally to the contrary, will disagree with this view. Drilling and producing oil operators, however, are optimists. By deduction it can be stated, optimistically, that depth is an infinite dimension. A qualifying remark, however, is necessary. Oil accumulation is governed by sedimentary deposition and, therefore, there are geologic limits to depth.—J.M.

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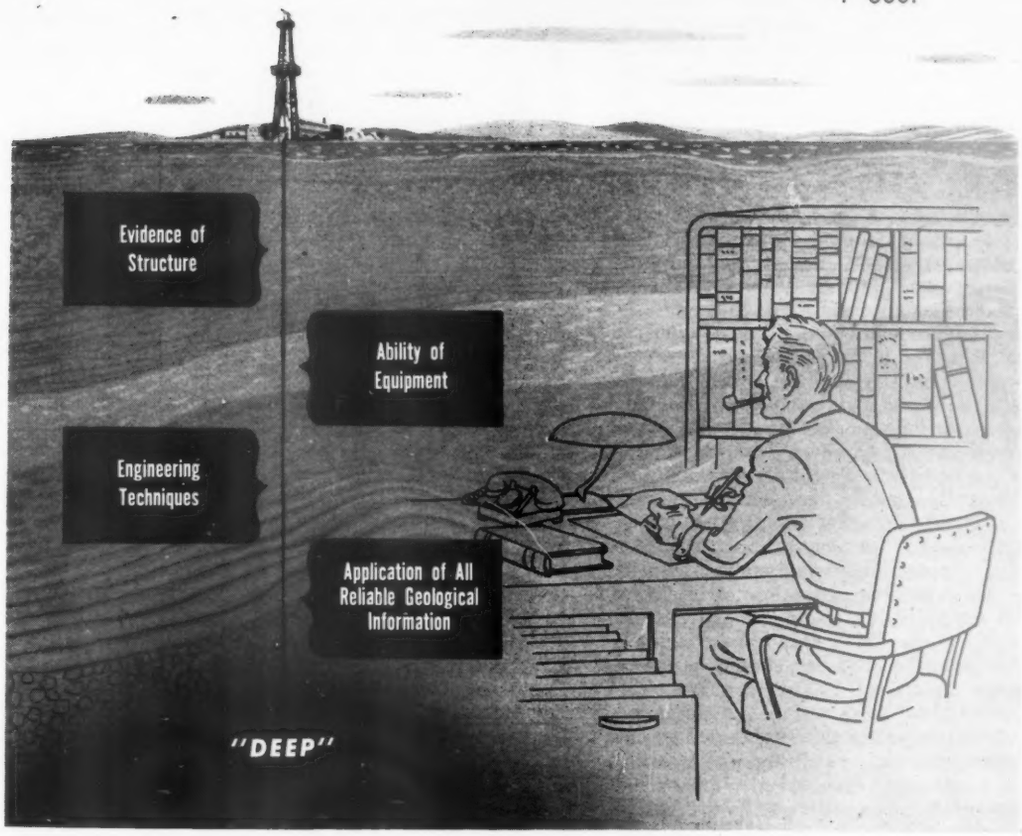

Before an exploratory test can be permanently classified as "DEEP," all possible mechanical, technical, and scientific knowledge must be exhausted.

A Geologist Thinks About Deep Drilling

An outstanding geologist here presents some thought-provoking views on the future of deep holes

G. FREDERICK SHEPHERD

An article written about the future of "deep drilling" in exploration for new oil should recognize three important ideas: "Deep," "deeper," and "deepest." Only the last of these connotes finality, and then only when followed by the word "possible." "Deep" and "deeper" are relative terms and must be considered in relation to time or circumstance. It can be recalled when an 8000-ft test was really a "deep test" and subsequently this figure was supplanted by 12,000, 17,000, and plus. This type of "deep" is in terms of record-breaking, for even today an 8000-ft well may be a "deep test," if it happens also to be "deeper" or "deepest possible."

In his presidential address read before the American Association of Petroleum Geologists at Tulsa, Oklahoma, March 19, 1936, A. I. Levorsen said: "We began looking . . . at the surface by surface methods and we have progressively deepened the plane of our search until we are now actively searching for domes which occur at depths of 5000 to 10,000 ft and in some areas even deeper. The present wave of seismic exploration at these great depths might be said to be the last stand of local structure to escape detection and these geophysical methods are rapidly finding all of the folds and local deformation which were missed by previous methods."

Later in the same address Dr. Levorsen said: "Since the search for domes . . . has been our chief method of attacking the problem of oil discovery, and if we are approaching the end of our supply of such structures for the very reason that we are rapidly exhausting our finding methods down to the lowest depths at which we can drill oil, then what of the future?" The present paper reveals what at least one geologist thinks about the future—the future of deep drilling.

Only 17 years ago, 4 years after the deepest test in the United States had been drilled in Oklahoma to a depth of 10,079 ft, Warren L. Baker published an article under the title "10,000 Foot Drilling Has Definitely Arrived and Is of Economic Significance." Three years later William L. Strang wrote an article entitled "Vast Advancements in Deep Drilling Equipment Make 18,000 Foot Holes Possible." Who will write under the title "30,000 Foot Drilling Has Arrived" and when? Who will be the first to dare to use any depth figure and say "this is the deepest possible"?

Recently, the readers of *Time* magazine were given an excellent layman's view of the success that has come to one of our major oil companies as the result of exploring the frontiers of geological thinking. In closing this story, the author stated that "oilmen estimate that of 2,400,000 square miles on the earth where oil may exist, only 1 per cent has ever been explored." As we see it, this would be more completely correct if the estimate were made in terms of cubic miles, and then what would be the percentage of past exploration? Surely there is a tremendous future both geographically and subterraneanously. For

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many decades to come new oil will be discovered as long as there is a demand for its products and as long as the price paid for these products justifies its production.

Depth

What is "deep"? Is it not that depth to which a well can be drilled with available equipment and technique and within economic limits? And, are not the economic limits defined differently among operators? Frequently, the so-called economic limits are not arrived at from the profit motive, rather by the reason for drilling the test. Certainly the Bahamas Oil Company No. 1 Andros, drilled in 1946 in the Bahamas, would be considered a "deep test," and the cost of this would be recognized as beyond economic limits except that the operators deemed it a worthy enterprise in light of the stratigraphic and geologic information sought and obtained.

In turning the attention to the future of deep drilling in respect to "deepest drilling possible" one asks "what is basement" and "when should basement tests be drilled"? This cannot be restricted to wildcats drilled in areas where no production exists today, because exploratory drilling will continue in producing areas and also on wildcat prospects. The first well drilled in Orange field, the second deep salt dome discovered in the Texas Gulf Coast, was drilled in 1903 and first production in this field was obtained in 1913. What would the drillers in that decade have thought if they were told that new oil would still be drilled on that same structure in the 1950's? Orange field is not by any means unique in this respect.

To illustrate "deepest drilling possible" assume a wildcat prospect located in the Midland Basin where production may be obtained from shallow Permian strata to Ellenburger below 13,000 ft. On drilling a *bona fide* test of a prospect defined by reliable geological or geophysical information, two basic factors must be determined: Does the test confirm the existence of the anticipated structure and where should the well be completed if the drilling is successful?

Shallow markers may confirm the structural anomaly and this may be strengthened by substantial shows of oil or gas. If no show is considered potentially commercial, a prudent, prescient operator will continue drilling as long as he has reason to believe he is drilling on structure and until there is no possible production to be anticipated by deeper penetration. How many wildcatters have bragged about the discovery well they drilled "deeper" than a former operator had, and abandoned? The "deepest possible" depth of a wildcat on structure in the Midland Basin is solid granite or other pre-Cambrian metamorphic. Have a sufficient number of wells been drilled below the upper Ellenburger to *prove* that lower Ellenburger, Cambrian, older detrital, or other deposits above granite cannot be oil-bearing? If not, more wells should be drilled to basement and the effort and expense may be justified.

The Author

G. Frederick Shepherd has since 1951 been assistant vice president with General American Oil Company. A graduate of Hamilton College, he studied at Northwestern University and the University of Chicago. He was employed by Phillips Petroleum Company from 1936 to 1940, when he joined Lane-Wells for a year. From 1941 to 1946 he worked for William Helis, when he became a consulting geologist. He joined General American in 1948 as chief geologist.

End Point

The end point for geologists to obtain in exploration is a map showing all producing areas and satisfactory proof that all intervening and underlying acreage is condemned forever. Actually this applies to the entire "2,400,000 square miles," if you will. *Proof* in this respect does not mean a geologist's opinion that an area is not recommended for a test, nor does it mean a dry hole stopped by an operator before it has reached basement. How few acres of land, how few cubic miles of earth could be blanked out as positively condemned from future exploration in proportion to those on which and in which productive possibilities remain? Until the ratio is reversed one need not fear exhaustion of the reserves, in spite of forecasts made to the contrary, nor should the geologist cease his efforts in finding new oil.

In thinking about the future of deep drilling, therefore, the aim is at this exhaustive study, which spells finality to exploration. Returning to the Midland Basin prospect, assume the situation where multiple pays are encountered. Instead of confirming a structural anomaly by correlation, augmented by noncommercial shows, the test penetrates satisfactory indications of oil production, first at shallow depths, and then in lower horizons. When the operator first encounters a commercial pay he has to decide whether deeper drilling will jeopardize the success of a shallow completion. There are obvious exceptions in this case, but is not the most reasonable answer, the fact that the shallowest pays are the least expensive to drill, or redrill, if necessary, and should not basement be penetrated on the initial test?

It is recognized that an unknown water table is a hazard in deeper drilling after reaching a shallow pay, particularly when drilling in permeable limestone where it may be very difficult to shut-off sulfur water below the contact with oil. The contention made here is that if, for example, only 30 ft of San Andres is oil-bearing and this is underlain by a substantial thickness of water-bearing limestone, is it not advisable to determine this on drilling the first well instead of stopping just above water and assume an "unlimited" thickness of the reservoir? If the remaining drilling is unsuccessful and a plug-back fails to make a producer, the operator has had an opportunity to evaluate his prospect as well as the chance to discover deeper multiple pays. The loss of what might have been a short-lived producer could be compensated for by the saving of the cost of unnecessary dry holes. Drilling through a pay zone on the first well certainly gives information of dollar importance in planning development drilling.

Perhaps this argument weakens at greater depths. If no production is found above the Devonian, for example, and a commercial well is indicated in the top 100 ft of that horizon, should the well be carried to basement? In the Midland Basin, where Devonian may be 10,000 to 12,000 ft deep, and the cost of penetrating it approaches or exceeds $200,000 it would take a courageous operator to drill the Devonian chert and continue to basement on the first well. The same argument used for the San Andres still applies, however, until basement has been reached, but if the first well is not carried to basement, the second, or confirmation test, should examine *all* productive possibilities. Wells are excluded here, of course, in which mechanical problems or other well conditions do not permit deeper drilling.

If there is any merit to the argument for drilling basement tests in the Midland Basin or other areas in which there is available a considerable amount of geological information, then there is great merit to the same argument when applied to unexplored territories. In the Delaware or San Juan basins, for example, deep exploration is relatively new and unknown. How much there is to learn about oil-bearing strata at depths in these basins! But what of a vastly different area, such as where great thicknesses of unpenetrated sediments are known to exist? Alaska, northern Canada, and many other parts of the world have within their boundaries such sedimentary deposits of which little is known. It is not suggested that the time has come to embark on extensive deep exploration programs in many of these areas, but no one would doubt that that time will come in the future. When it does arrive, enormous expenditures will be made in geological and geophysical research and exploration before the first drilling commences. Should such expenditures be made only to be followed by shallow drilling to the first pay to be encountered?

It would appear to be false economy were a new territory to be drilled and developed in a shallow pay only to have the same area re-drilled later and after someone ventured below that pay to discover deeper zones. The real economy, on the other hand, would seem to

be to drill and develop the "deepest possible" zones first with the knowledge that multiple shallower pays existed behind the pipe for future production.

Prospects

The operators have the right to ask geologists what are the prospects in sight in "deepest drilling possible" and it is their obligation to provide an adequate answer. The truth is that too often the geologist does not know the answer. If he admits that he does not know what oil production possibilities exist between the depth of his own observations and basement, why should any operator risk large sums of money to find out?

To answer this question the geologist must follow basic principles and concepts too often abandoned for more positive evidences or opinions. One of the foremost factors required for oil accumulation is structure, whether shallow or deep. Unless evidences of a structural anomaly have been recognized by the time a well is "deep" there is little reason to drill "deeper." What are some of the evidences to be sought and recognized? If a rank wildcat is being drilled, remote from any subsurface control, and a geologist has contoured the area regionally with scant control and a deep marker is encountered "high" in reference to his interpretation of the regional subsurface attitude, it may not be enough to satisfy the operator to continue to basement. If the "high" marker comes in at relatively shallow depths and lower markers increase the magnitude of the anomaly, it would be encouraging and one might safely predict that the well is being drilled on structure. If this is all the evidence there is, the answer to how deep should the well be drilled will be found in economic, contractural, and other considerations.

If recognizable markers have established the well as running high, and numerous shows of oil or gas have been encountered, assuming them to be noncommercial, the value of these shows lies in the fact that they have probably confirmed the presence of the structure. One must make sure that the shows have been the result of a structural anomaly in applying this principle. Oil that exists in a permeable medium has to be explained, and if the explanation is that the oil is present because of a structural trap, then the answer is to go deeper—to basement.

Such evidences of structure may be enough for the geologist to reach his decision and make his recommendation. There are, however, other basic factors to be considered. His knowledge of regional and stratigraphic geology in the area may be inadequate to enable him to say that potential oil-bearing strata may underlie the test in question. But how many now-producing formations were unknown at the time they were first penetrated? It would be an ultraconservative geologist who would say that he had evidence that no possibilities lay ahead unless he had nearby control adequate to constitute proof.

It is not within the scope of this article to outline the areal or stratigraphic geological conditions of the oil basins of the world, nor could such be done with much accuracy or completeness from the standpoint in which this is being written. For an example, however, if the test in question in the Midland Basin were being drilled in the zone in which Cambrian and lower Ordovician seas invaded, one may have numerous wells that have been Ellenburger tests and have stopped after encountering water in porosity near the top. How much is known of permeability in lower zones of the Ellenburger? What types of porosity are persistent enough for a geologist to say that the lack of porosity or permeability in the lower Ellenburger in one well is evidence that the same zone in another well also lacks porosity or permeability? Literature on the Ellenburger formation of Texas is abundant and helpful in providing a regional knowledge of the character and distribution of this formation, but where in all that vast literature will one find any statement to the effect that any subdivision of the Ellenburger cannot be oil-productive where it is encountered on structure? Parallel to the matter of permeability is the degree of completeness and positiveness of our knowledge of sedimentary facies throughout the entire area underlain by these strata. The same questions take on greater significance when one asks what lies below the Ellenburger? These are the questions to be answered before the geologist's end point, which have been defined above, has been reached.

Levorsen's same presidential address referred to above was an argument for applying our best geological and geophysical methods to exploration for oil resulting from stratigraphic accumulation versus structural accumulation. He defines a stratigraphic trap as "one in which a variation in the stratigraphy is the chief confining element in the reservoir that traps the oil." In 1936 little attention was paid to methods essentially directed to finding oil in stratigraphic traps, but the geological profession would be sadly negligent if in the last fifteen years it would not have shown considerable progress in this important field of endeavor. No one would claim, however, that one has achieved that degree of geological or geophysical perfection that could enable him to detect stratigraphic traps at great depths prior to drilling. It is admitted that the collective knowledge of the geological profession contains vastly greater intimacy with conditions under which stratigraphic traps occur, but whether this has advanced far enough to permit one to explore intelligently for oil reserves that occur in such reservoirs is a matter of doubt. Thinking of the future of deep drilling, however, it would be amiss to admit that scientific methods were incapable of discovering stratigraphic traps. Much work remains to be done before this can be accomplished.

There is general knowledge regarding many major regional unconformities that occur beneath the earth's surface and in many instances much is now known of the stratigraphic and structural conditions beneath these unconformities. Of those important unconformities yet to be discovered what lies ahead in exploration at greater depths? Will stratigraphic methods of exploration ever reach the point where oil accumulated in stratigraphic traps can be detected prior to drilling or shall one rely on the venturesome wildcatter to find these new reserves by accident? Whatever the method of finding such new oil reserves may be, their very existence remains a challenge and an objective for deep drilling in the future.

The observation of the author of an article entitled "Drilling Is Deep in the Permian Basin,"* is well taken at this time. He points out that the shallow oil was easily located and quickly produced and deeper drilling was the answer to the demands created by the practice of conservation and by the heavy consumption in World War II. After 1942 formerly unknown formations became productive and the results are that by mid-1951, the total cumulative production in West Texas exceeded three billion barrels. Cannot history repeat itself again, and again until that end point is reached when the geologists truthfully say "there is no more oil to be found?"

The same problem of what lies below is geologically simpler and at the same time accompanied by more severe drilling problems when applied to the Gulf Coast. It was stated earlier, however, that "deep" is that depth attainable with available equipment and technique. Perhaps it was something of this thought in mind that the advertisers of a well-known piece of equipment recently described that equipment as "... for deepest drilling." If maximum depths are to be drilled anywhere, it will probably be in the Gulf Coast or off-shore. What is the limit in such a vast area of exploration?

There is an obvious basement in the case of salt domes, being the main salt mass, differentiated from salt overhangs or salt stringers near the salt dome that spells finality to drilling on a dome. One thinks of deep drilling on salt domes in the same light as drilling extension tests or tests in new fault segments surrounding a dome. In the early days of salt dome exploration, oil was sought in or above the cap rock at relatively shallow depths. It was soon learned, however, that salt domes were complex structural uplifts, accompanied by intensely upturned sands and shattered by intricate fault patterns that made exploration on the flanks of salt domes a challenge to geological subsurface thinking. Drilling on the flanks of these salt domes will continue for decades before the last reservoir existing thereon is fully developed.

Future Limits

Differentiated from extension tests, and tests in fault segments on flanks of salt domes is the future of deep drilling. Various estimates have been made as to the depths of the parent salt mass from which the domes were squeezed, but it is generally recognized that the effect of the salt intrusion on surrounding sediments is felt to "greatest depths." Ex-

*Drilling, January, 1952.

amples could be cited from scores of salt domes on the Gulf Coast where recent drilling has stepped out great distances from the recognized top of the dome only to find new untapped reservoirs of considerable magnitude. At Lake Washington, Plaquemines Parish, Louisiana, for example, sulfur has been produced from the top of the dome for years and during the past three years deep drilling has proved the flanks productive at great distances from the top and at depths from 8000 ft to 14,000 ft and at the present time drilling is in progress below 16,000 ft.

What is the limit to deep drilling in the Gulf Coast? The answer applies to piercement salt dome flanks, deep seated salt domes, and to drilling on any structural anomaly discovered in this great sedimentary trough. No one would doubt that power requirements will be met for whatever drilling problems are faced, but many persons will point to the tensile strength of tubular goods and to the material strength of threads on drill stem joints or casing joints and say the limits of deep drilling is approaching. Others, however, will turn to the metallurgists or to chemists engaged in synthetic researches and will not be greatly surprised when they learn that the depth limits have been extended again and again. Mud technicians and engineers whose responsibility it is to keep pace with deep drilling problems will join the metallurgists and chemists in approaching the "deepest drilling possible." The geologist will hold one position throughout this progressive extension of depths of penetration and that is, that as long as wells can keep drilling, there are possibilities of finding new oil. There is no limit until manufacturers of equipment and drilling engineers say "we can't go any deeper."

Stratigraphic oil at great depths in the Gulf Coast offers the same challenge as oil accumulated on salt domes, but the methods employed in its discovery have not been developed to their maximum. One detriment to deep drilling for such reserves is the attitude, too often displayed, that sand sections have been passed and only shale can be expected by drilling at deeper depths. This may be true in some cases, but many new zones of productive oil sands have already been discovered where deep wells have penetrated enormous thicknesses of sandless shale formations. One thinks again of "deepest drilling possible" until that end point has been reached when it can be said with confidence "there is no more oil to be found." There is something to learn about the pre-Tertiary or even the pre-Cretaceous in the Gulf Coast before those words will ever be pronounced.

Many persons have been rewarded by applying themselves in the field of exploration to areas that are already productive. They need not expect all new oil to be found from wildcat exploration. "Deepest drilling" is worthy of "deepest thought," whether applied to rank wildcats or "deeper drilling" wildcats. It is already too late to talk about the depth to which the first well should go in a producing field. That well may have been drilled 20 or more years ago, but in these areas lie perhaps the happiest hunting grounds.

The woods are full of excellent examples of profitable deeper drilling in old shallow producing fields. One of the best is the Haynesville field, Claiborne Parish, Louisiana. Wells are still finding new oil in this field, 32 years after its discovery!

The shallow pay of Haynesville field is the Blossom sand at the top of the Tokio formation, Upper Cretaceous age. The discovery well, the Smitherman-Palmer et al No. 2 Anna Taylor, penetrated 6 ft of this sand at total depth of 2856 ft and was completed March 30, 1921. As of January 1, 1946, there were 186 wells still producing from this sand and the cumulative production was nearly 75,000,000 bbl.

It was not until January 25, 1927, that the first Lower Cretaceous pay was encountered in this field and this discovery well, the Gilliland Oil Company No. 1-D G. W. Taylor, was only 4000 ft from the first discovery well. This "deeper" production came from the Hill sand zone of the Rodessa formation at a depth of 4529 ft after plugging back from the total depth of 5092 ft.

On November 24, 1941, twenty years after the field's discovery, the Pettet producing zone of the Sligo formation at a depth of 5431 ft, was completed in the T. L. James and Company No. 1 Mrs. L. F. Aiken. Prior to this, however, the field's first "deepest" test had been drilled and abandoned as a dry hole at 11,274 ft. This deep test was the Ohio Oil Company No. 15 G. W. Taylor and it was drilled after detailed reflection seismograph exploration had been conducted by the operator. After the Pettet production had been established the Ohio deep test was completed as a Pettet producer and later it was recompleted to discover the Taylor sand production in the Cotton Valley formation of Jurassic age. The depth of this production was from 8800 to 8900 ft and the well was completed November 19, 1944.

Another Cotton Valley sand, the Camp sand member, 1000 ft above the Taylor was discovered in the following year with the completion of the Blackwell Oil and Gas Company, et al No. 1-A Waller-Beene, June 28, 1945. A history of this field, published in 1946, states that the Taylor sand is the "deepest producing horizon" established in Haynesville field. It did not state "deepest possible producing horizon," but only the deepest as of January 1, 1946. Since that time, production has been found in the Smackover formation and in oolitic limestone of the Haynesville Pink formation, formerly referred to as the Smackover "A" Zone. Subsequently, the Burns Reef has been found in the East Haynesville sector of the field and a similar reef is now producing in the West Haynesville part. The 11,274-ft dry hole, however, had been drilled nearly 300 ft below the top of the Smackover formation. With a discovery record such as belongs to this great field, who is going to say that no more new oil is to be discovered in Haynesville field?

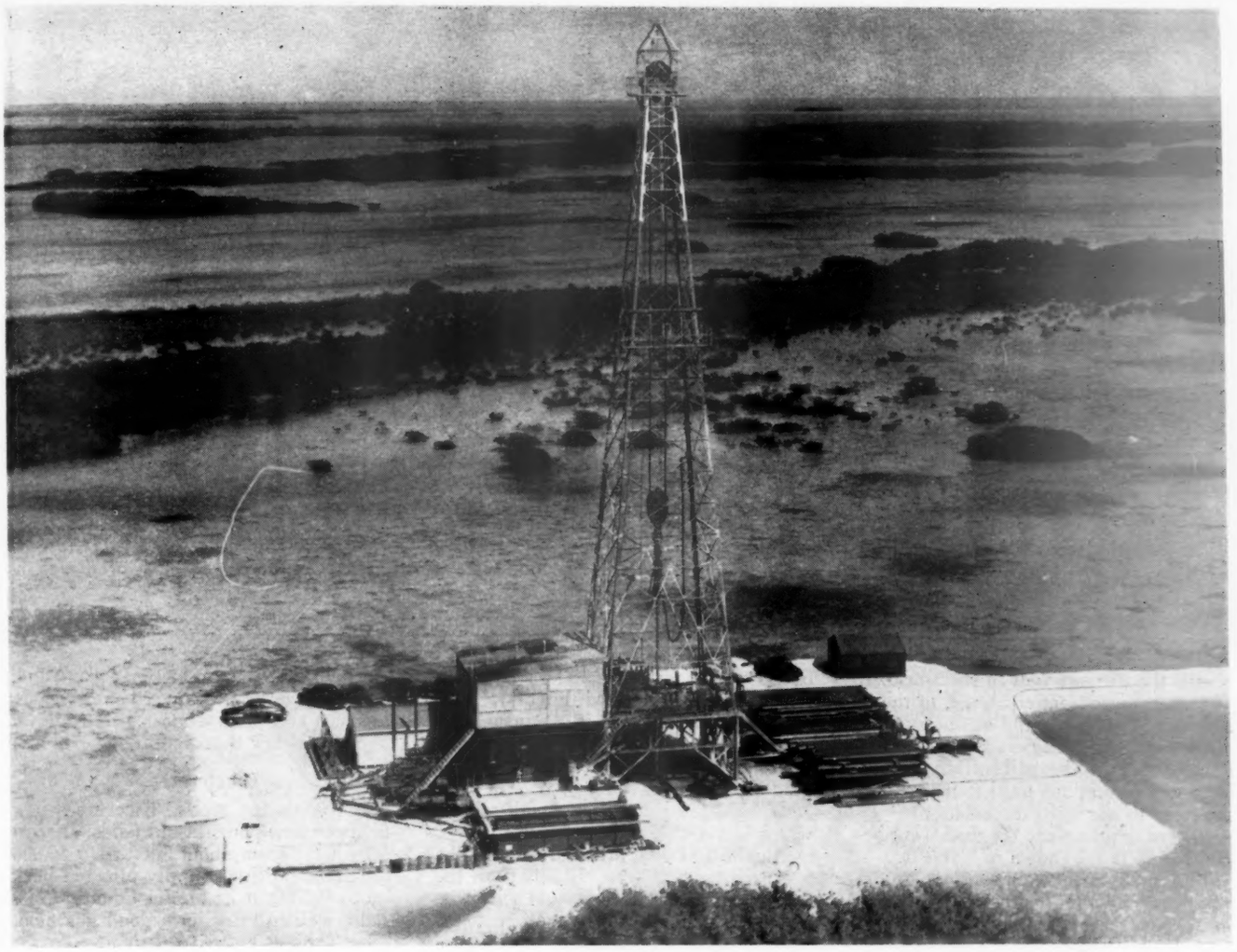
Geologist's Choice

This paper is directed toward "deep drilling" in exploration for new oil and does not include new oil to be found in extension tests or in exploration based on revised structural interpretations of older fields. In the future of deep drilling as here considered, geologists have much to gain by studying the past and avoiding the mistakes of the past. It is true that advanced techniques have enabled geologists to find oil that would have remained undiscovered before these techniques were known and practiced, but the fact remains that many producing zones of oil are penetrated without recognition. Perhaps one of the reasons for this is that when a new test is projected, geologists are asked what the objectives are and he too frequently defines certain well-known horizons of the area in which the well is being drilled and perhaps thereafter limits his investigation of this well to the examination of only those objectives. If a North Texas well is projected to the Caddo Conglomerate, perhaps the operator is satisfied when he is told that the conglomerate is present or absent, porous or tight, oil-bearing or water-bearing. But has the geologist fulfilled his obligations with these answers? Has he proved the absence of any oil in the Cisco or Strawn sands; has he proved that no oil could be produced from the Ellenburger? Only a fully examined test drilled to basement can give these answers.

Many oil fields have been discovered by accident and many will continue to be so discovered, but the geologist has a profound duty in respect to exploration for oil. Whether drilling in the Gulf Coast, Mid-Continent, Rocky Mountains, or in foreign lands, there is one rule that can be followed to find oil "on purpose." It is perhaps a point of view instead of a rule or principle. It is the antithesis of the practice of reporting, on investigation, the presence or absence of oil in a given objective. A geologist can take his choice: Is every permeable stratum barren until proved oil-bearing; or, is every permeable stratum oil-bearing until proved barren? If the geologist can supply the proof and evidence in answer to the second choice of questions, he will eventually reach his end point in exploration for new oil. Until then, others will profit by his mistakes. Every permeable stratum contains oil that does not furnish proof of its absence where that stratum occurs in accordance with known and well-established principles governing the occurrence of oil: Structure or trap, cap, source bed, etc.

Bibliography

The bibliography on deep drilling is too large to be included in this paper, but it is an inspiration to the thinking geologist to review from time to time the literature on this subject. A good start will be found on pages 441-446 of DeGolyer and Vance: "Bibliography on the Petroleum Industry," *Bulletin of the Agricultural and Mechanical College of Texas*, Fourth Series, Vol. 15, No. 11, September 1, 1944. ★ ★ ★



Gulf Oil Corporation No. 1 State of Florida, drilled to 15,155-ft, is deepest well in Florida.

Depth—The Third Dimension Frontier

A fortune turns on the rotary table when the drilling bit cuts below 15,000 ft in deep pioneering territory

ERNESTINE ADAMS*

THERE is a lot of talk about the lack of frontiers today. Expansion over the earth's surface is at the expense of those expanded into and areas seem to be contracting. But the petroleum industry has its own particular frontier and operators are digging away at it with a strong will and tremendous skill. It is not the length and breadth of the land, although these dimensions, too, are being explored. No, this challenging frontier is about 3 miles straight down. It is the third dimension—depth.

The earth is a lot younger down there. It once contained life but no human footprints ever marked its sands. Now it is being invaded by the curious, courageous, geology-happy, profit-seeking U. S. petroleum industry.

Seventy wells in the United States have been completed below 15,000 ft in 9 states. Only 3 outside the United States have been completed in those depths; these are all in Venezuela.

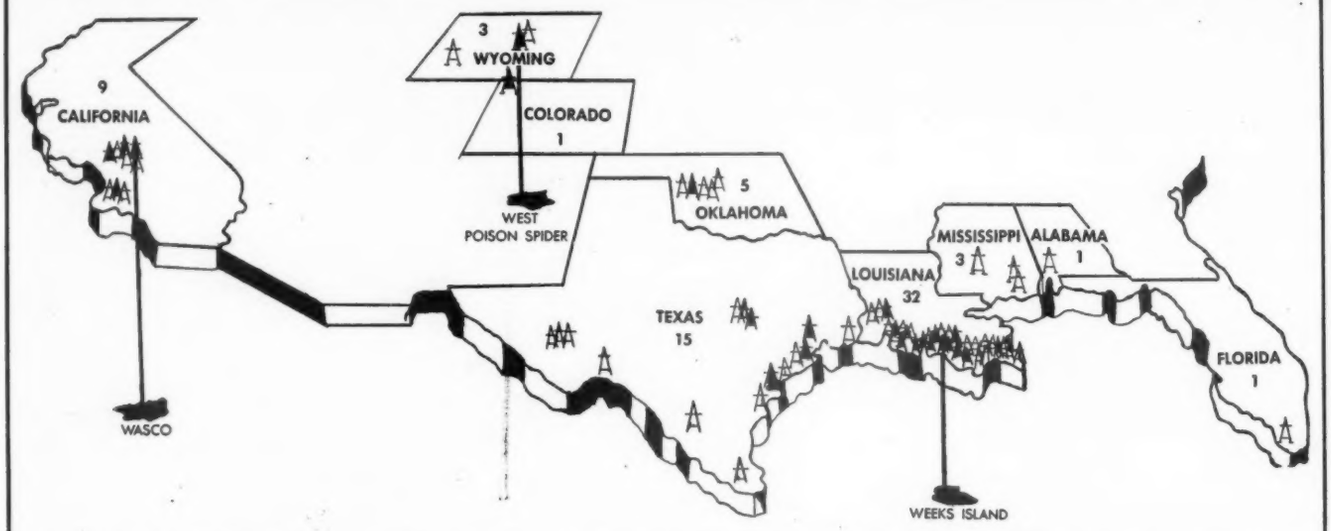
The petroleum industry has been very busy pushing into depths since the first well was drilled. It took 50 years—from 1859 to 1909—to penetrate below 5000 ft, but after that the drill went down faster. Here is how the frontier has been deepened:

Date	Record depth below	Date	Record depth below
1909	5,000 ft	1935	12,000 ft
1917	7,000 ft	1938	15,000 ft
1927	8,000 ft	1944	16,000 ft
1929	9,000 ft	1947	17,000 ft
1931	10,000 ft	1949	20,000 ft
1934	11,000 ft		

Superior Oil Company Pacific Creek Unit No. 1, drilled to 20,521 ft in 1949,

*Managing Editor.

EXCLUSIVE



States with deep wells and deep production. Figures in state indicate number of wells below 15,000 ft. The three fields producing below 15,000 ft are Wasco, West Poison Spider, and Weeks Island. The first two fields have one well each producing below 15,000 ft; Weeks Island has seven producing at these depths.

is still the deepest well in the world. It puts the depth frontier almost to the 4-mile line. Can you stand on the surface of the earth and imagine 4 miles down? Can you imagine the drill cutting through scores of formations until it moves into the front of the third dimension?

Record depths since the drill went below 15,000 ft are shown in Table 1.

The first well outside the United States to be drilled below 15,000 ft was Caribbean Petroleum Company No. 2A Curacao in Cabimas field, Western Venezuela, which was completed in June 1947. The deepest hole now is Creole Petroleum No. 1 Alturitas, with a depth of 17,093 ft.†

Production

As in the covered wagon days this depth pioneering isn't for fun. The daring find oil down there—not enough to inspire another gold rush of the California kind but enough to beckon more drills to subterranean depths.

Pure Oil Company found enough oil at 16,102 ft to complete for production at West Poison Spider No. 3, Natrona County, Wyoming. This is the deepest production in the world unless the Russian Soviet has a secret deeper one, which is anybody's doubt.

The West Poison Spider well flowed 57 bbl a day with 442,000 cu ft of gas when it was completed January, 1952. A pump was installed in August, 1952, set at 8000 ft, about half way down, and the well is now pumping. In the same field West Poison Spider No. 1 in July, 1948, held the production depth record, which was 14,309 ft.

Standard of California Mushrush No. 5 is still flowing from 15,530 ft in the Wasco field, Kern County, California, where discovery of a new deep pool was made in February, 1949. Its initial production was 352 bbl of oil and 1218 cu ft of gas a day. (See Page B-91.)

But the deep bonanza is Shell's Weeks Island*, deepest field in Louisiana and the one with the largest daily production—about 20,000 bbl a day. Of the 70 U. S. wells below 15,000 ft, 10 are in Weeks Island and only one is dry. The Shell Gonsoulin-Minvielle No. 1 is the deepest producer with oil sand at 15,336 ft. This well came in August 3, 1951 with 480 bbl of oil and 552,000 cu ft of gas. The other 9 deep producers of the field averaged better than 500 bbl of oil a day initially.

In January, 1945, I wrote an article entitled "3-Mile Production Near" and, comparatively speaking, it was. There are now two pools almost 3 miles down and one below that depth.

Discoveries

Eleven giant wells discovered new fields or new pools in old fields. Discoveries were from about 5000 ft to 16,000 ft. Mountain Fuel Supply plugged back up to 4930 ft at its Moffat County, Colorado, well to bring in a good gas field. (See Table 2.)

Continental Oil Company in San Miguelito field, Ventura County, California, had production at intervals from 8742 ft to 14,480 ft and was completed at the shallow depth in the Third Grubb zone as the best. Initial production was 1311 bbl of oil and 1,157,000 cu ft of gas.

Continental hit the depth frontier first. In 1938 it drilled the KCL No. A-2 in Wasco field to 15,004 ft and brought it in producing 3384 bbl of oil and 1,536,000 cu ft of gas a day from 13,175 ft.

Besides the 11 super-depth wells that found new oil sands, 14 others are producing. Some of these were wildcats at depths and were plugged back to field production. Others, like the Weeks Island wells, were drilled to deep production as field wells.

†See page B-98 for table.

*See Weeks Island by J. W. Pittman and J. E. R. Sheeler in *The Petroleum Engineer*, March 1952, Page B-7.

TABLE 1. Record drilling depths.

Year	Company and well	Depth, ft
1938	Continental No. A-2 KCL, Kern County, California	15,002
1945*	Phillips No. 1 Ada Price, Pecos, Texas	15,279
1945	Quintana No. 3-D So. Texas Syndicate, McMullen, Texas	15,301
1945	Standard of California KCL 20-13, Kern County, California	16,246
1945	Phillips No. 3 Schoeps, Brazos, Texas	16,655
1947	Pacific Western 1 Nat'l. Royalties, Kern County, California	16,668
1947	Superior No. 51-11 Weller, Caddo, Oklahoma	17,823
1949	Superior No. 1 Pacific Creek, Sublette, Wyoming	20,521

* Some 1945 wells reached record depths in 1944 before completion.

TABLE 2. Oil and gas discoveries made by 15,000 feet wells.

Year	Company and well	Found	Producing depth, ft	Initial production	Field	County, State
1952	Mountain Fuel Supply Unit No. 1	New field	4,889–930	21,000 MCF	Hiawatha	Moffat, Colorado
1949	Humble No. 1 McWatters	New sand	8,315–400	2500 MCF	Freestone	Freestone, Texas
1950	Continental Oil No. 65-E Grubb	New sand	8,742–930	1311 bbl 1157 MCF	San Miguelito	Ventura, California
1952	Richardson & Bass No. 1 Luma Darbonne	New field	11,976–986	144 bbl 580 MCF	Oberlin	Allen, Louisiana
1949	Union Producing No. 2 Buckley Mahler	Extended field	13,378–386	792 bbl 27,000 MCF	Delarge	Terrebonne, Louisiana
1947	Texas No. 1 Lafourche Basin Levee District	New sand	13,879–904	48 bbl 6188 MCF	Queen Bess Island	Jefferson, Louisiana
1938	Continental Oil No. A-2 KCL	New field	13,150–175	3384 bbl 1536 MCF	Wasco	Kern, California
1951	Texas No. 6 Kling-Walet	New sand	14,126–144	486 bbl	Fausse Point	Iberia, Louisiana
1949	Shell Oil No. 1 Weeks-Gall-State Unit No. 1	New sand	14,150–165	574 bbl 651 MCF	Weeks Island	Iberia, Louisiana
1949	Standard of Calif. No. 5 Mushrush	New sand	15,440–530	350 bbl	Wasco	Kern, California
1952	Pure Oil No. 3 West Poison Spider Unit	New sand	15,932–102	57 bbl	West Poison Spider	Natrona, Wyoming

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Only 9 wells in the world are producing from below 15,000 ft. Seven of these are in Weeks Island field, one in Wasco, and one in West Poison Spider field.

The only two deep wells completed for production from two sands belong to Superior Oil Company. In Pecan Lake field, Vermilion Parish, Louisiana, the 16,500-ft Miami Corporation B-8 is completed at 10,166-76 ft and 11,666-78 ft. In the Portella field, San Patricio County, Texas, Superior's Minnie S. Welder is completed at 7284-90 ft and 8107-15 ft. Each of the four sands came in for two to three hundred barrels a day.

Lion Oil No. 2 Denkman Lumber well in Rankin County, Mississippi, produced carbon dioxide. Phillips No. 1 Delta Wilson is shut down in Val Verde County, Texas. Superior No. 3 South Texas Development Company is a Wilcox injection well for Lake Creek field.

Several deep wells discovered oil and gas but the production was considered uneconomic.

Costs

It is the economics of the deep drilling operations that deter the potential depth rush. You can't safely pioneer along the third dimension frontier without a million or so U. S. dollars and you must be in a position to take a complete loss.

The average cost of below 15,000-ft holes so far drilled is about $550,000 but this ranges from about $300,000 to $2,000,000 and includes both wildcat and field wells. In fact most of the wildcats are exploratory only at great depths. The check for foreign ventures is still higher. Of course, you might go along with the day-to-day method and sell a thousand feet of geological information at a time and head right for China but it must be in a spot where the demand for data is intense.

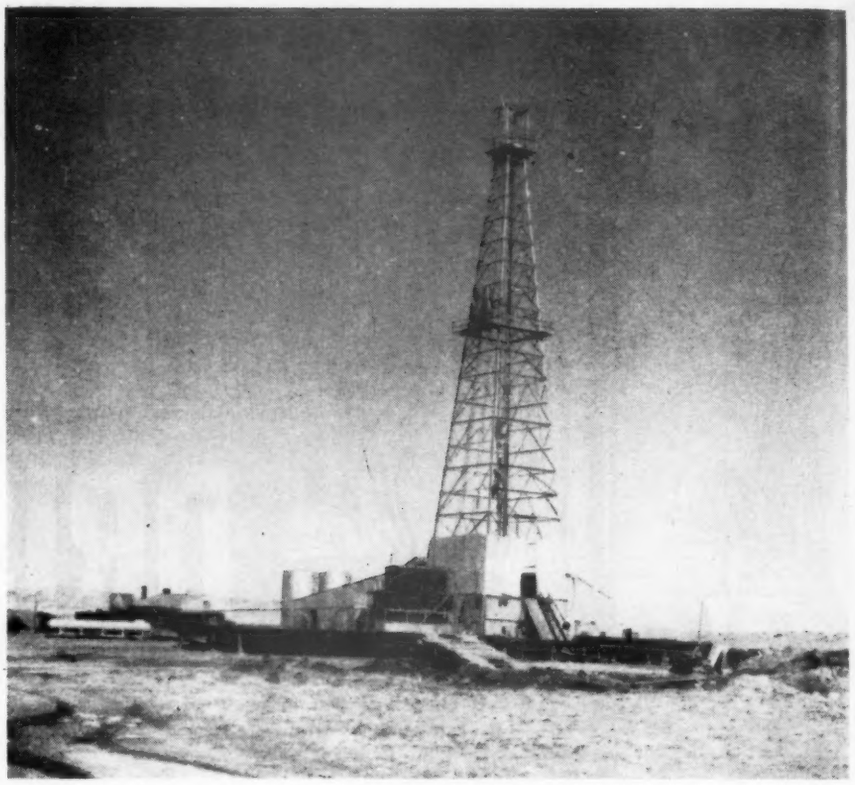
After spending some $40,000,000 to drill 70 wells below 15,000 ft in the U. S. the deep operators haven't fared so bad. If all 70 operations were entered in one financial statement the new frontier appears to be economic. Some companies have had to check off the deep holes as complete financial losses, yet they are ahead in valuable geological information. Others have been able to complete for production in field sands and still others have found rich oil and gas sands.

Although many of the 23 companies that have drilled wells below 15,000 ft have had no financial return, the balance for all projects seems favorable considering the fact that these wells touch a strange and unknown frontier.

Cost of wells below 15,000 ft, drilling and completion, runs about $36 per foot with the average depth 15,994 ft. This is almost a fourth more than the footage cost of all wells below 12,000 ft estimated in 1950.* Average depth was 12,887 ft and cost per foot was $28.

But total cost of wells below 12,000 ft was estimated at $360,000 average in 1950 and today the wells below 15,000 ft average $190,000 more. Using average depths then and now for the two sets of deep wells, cost of the drilling from 12,887 ft to 15,994 ft average is more than $61 a foot. These figures are not exactly comparable but they help show the trend of rising costs with greater depths.

*"Treasure in the Depths," *The Petroleum Engineer*, December, 1950, Page A-33.



Deepest well in Colorado is Mountain Fuel Supply Company No. 1 Hiawatha Unit in Moffat County. It is 15,041 ft deep.

Operators

The number of companies pushing into the depth frontier is larger than you would think and the 23 companies named as operators are perhaps only a small portion of those who have taken risks on deep drilling. These operators (Table 4) run all the way from one-man independents to large corporations. Shell has drilled the largest number, which is 11, but 8 of these were field wells in Weeks Island. The Texas Company has drilled more deep wildcats than any other company, completing 7 holes below 15,000 ft.

Location

Louisiana leads the 9 states having wells below 15,000 ft with a total of 32 super-deep holes. The state has the most wildcats and the most field wells — 16 of each — and 17 of the 32 are producing wells. The best deep field so far discovered, Weeks Island, is in the Louisiana Gulf Coast (Table 5).

The second largest number of deep holes is in Texas, which has 15 wells below 15,000 ft. California has 9; Oklahoma 5; Wyoming and Mississippi 3 each, and Alabama, Colorado, and Florida each has one deep well.

The estimated costs of wells in various locations differ but these, too, show only a trend. For instance costs in California are affected by the one well drilled in 1938 when dollar costs were considerably lower than now. Also one of the most expensive wells, Standard of California's Mushrush No. 5, was deepened and costs on the old well were not figured in the estimate.

Costs in Louisiana were brought down by Shell's Weeks Island field wells. Although not by any means easy to drill and still high in costs, the drilling program for the field is pretty well set and the operator is experienced.

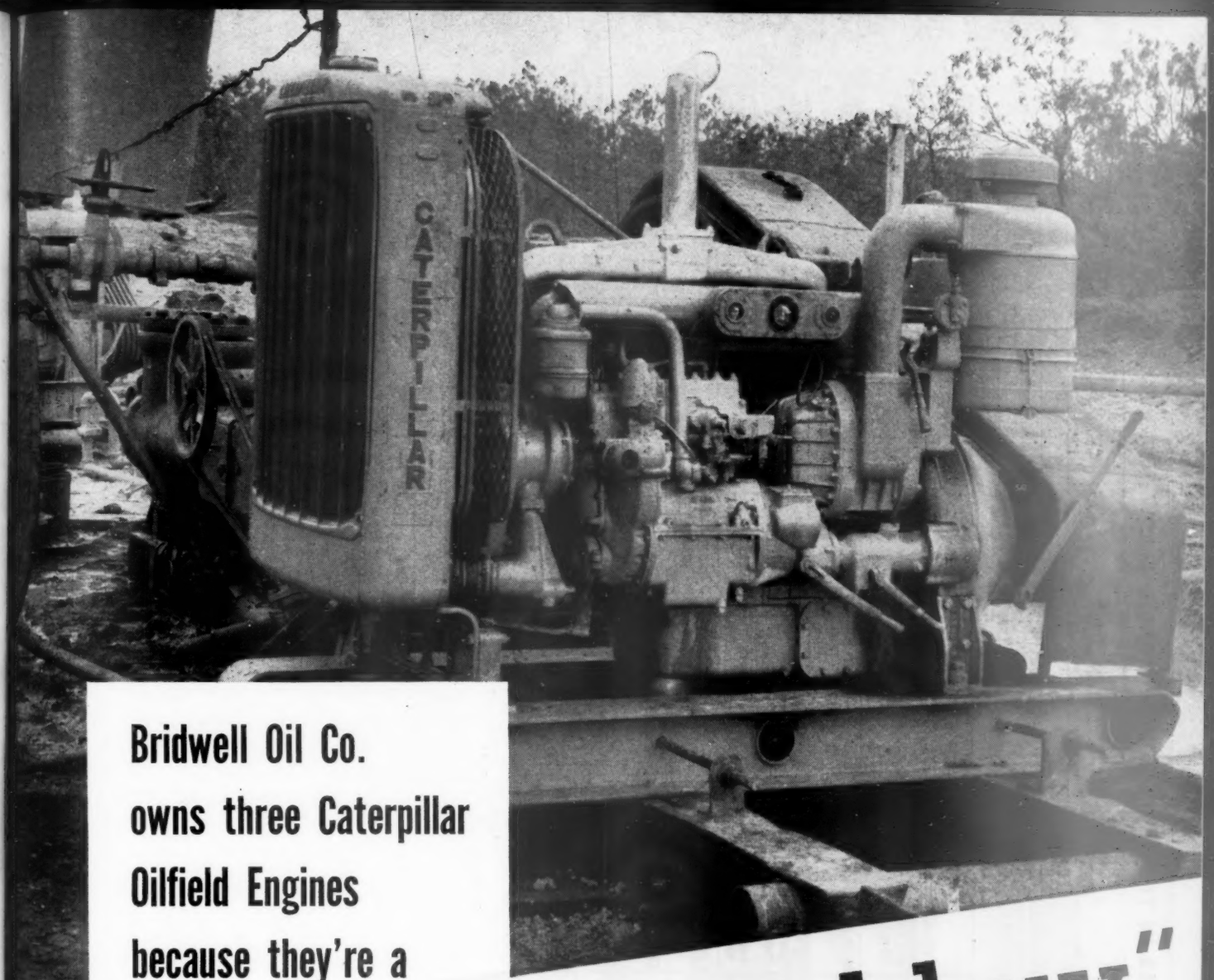
In Oklahoma the specially high costs are explained by the fact that all the Oklahoma wells were wildcats, drilling time was way above average, and number of bits required was high.

All 70 wells except one were drilled

TABLE 4. Operators of deep wells.

Company	Number	Wildcat	Production
Abercrombie, J. S.	1	0	1
Continental Oil	2	1	2
Denver Prod. & Ref.	1	1	0[1]
Gulf Oil	4	2	1
Humble Oil & Ref.	4	4	2
Lion Oil	1	1	0[2]
Little Nick Oil	1	1	0[1]
Magnolia Petroleum	4	4	0
Mountain Fuel Supply	1	1	1
Pacific Western	1	1	0
Phillips Petroleum	5	5	0[2]
Placid	1	1	0
Pure Oil	2	2	1
Quintana	1	1	0
Richardson & Bass	3	2	2
Shell Oil	11	3	9
Standard of California	4	3	1
Stanolind	2	2	0
Superior	8[4]	4	2[5]
Texas Company	10	7	2
Union Producing	1	0	1
Vasen, George	1	1	0
Western Gulf	1	1	0
Total	70	48	25

[1] Deep gas production not commercial.
[2] Produced carbon dioxide.
[3] One well shut down.
[4] One is injection well in Lake Creek field, Texas.
[5] Both dual completions of field wells.



Bridwell Oil Co. owns three Caterpillar Oilfield Engines because they're a "darn good buy"

The Caterpillar D337 Oilfield Engine pictured above is one of three Cat Engines used by the Bridwell Oil Co. of Wichita Falls, Texas, on oil drilling operations in Jim Smith County. It powers an Ideal mud pump. The reason this new 250-HP, maximum, unit was purchased was the outstanding record made by two D4600 Engines. One of them drives a Wilson-Snyder pump, and the other powers a compressor and pumps water to the drill rig. They have operated continuously since 1935 with only one overhaul! Enthusiastic boosters for Cat equipment, the Bridwell Oil Co. also owns a Caterpillar D6 Tractor with Bulldozer.

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TABLE 4. DESCRIPTIONS OF WELLS IN THE UNITED STATES DRILLED BELOW 15,000 FT

TD, ft Prod. depth	Company Well	Drilled by	Field County or parish	Compl't'd Spudded	Drill time, days	Casing and cementing schedule	Mud program	Bits, rock, drag and diamond	Cores Drillstem tests	Deepest form. Producing form., thickness	Perforations, production, pressures, choke, GOR, gravity, etc.	Remarks
						ALABAMA						
15,659 Dry	Humble No. 2 Williams	Ballew	West Chatom, Washington	2- 7-49 6-26-48	225	20"/66'-13⅜"/1856'-9⅝"/8945'	Lime, alkaline, tannate, starch max. wt. 10.8 #/gal.	186R	127 1 DS	Eagle Mills None	WC.	Deepest well in Alabama.
						CALIFORNIA						
15,004 13,175	Continental No. A-2 KCL	Company	Wasco Kern	4-19-38 6-21-37	284	10¾"/5512'-7"/11,573'-2898' 4½" CP at 13,005'-13,996'.		195	157 No DS	Domingine (Eocene) A-2 sand 25-40'	WC. 200 mesh perf. 13,092-175' & 14,049-315' IP 3384 B & 1536 MCF Ck 1" Psi-C 545 T 420; SC 1260 ST 1350# GOR 300.	At that time, deepest well in world and deepest production. Seismic selection; anticline.
15,092 Dry	Western Gulf No. 1 SP	K. L. Kellogg & Sons	E. of Paloma Kern	9- 2-47 3- 1-47	173	13⅜"/2329'-9⅝"/10,552' open hole below 10,552'.	Clay base to 14,354' lime Impermex below.	204R	30 No DS	Santa Margarita None	WC.	Greatest amount of open hole, 2320' to 10,552' and longest string of casing of that weight set at 10,552' at that time. Anticline.
15,550 Dry	Standard of Calif. No. 2 Mushrush	Company	Wasco Kern	7-29-52 6-10-50†		10¾"/8095'-6260' of 7" cmtd. 13,060'-2579' of 4½" Ld 15,548'.	65-92 Pcf oil base		29 5 DS	Eocene None	FW. Anticline structure. Old well completed 4-13-39 was deepened from 13,125'. Perf. 15,262-548'; 14,945-15,055'; 15,538-48'; 15,262-507'.	Well was idle 6-29-51 to 6-11-52.
15,866 15,530	Standard of Calif. No. 5 Mushrush	Rocky Mountain Drilling Co. & Standard of Calif.	Wasco Kern	9- 8-49 2-28-49†	95	13⅜"/1030'-9⅝"/8100'-6⅝"/ 13,053'-2899'-4½" Lnr. 15,863' Plug 15,535'.	Dld. water base Liner run emulsion base		34 No DS	Eocene Eocene	WC. Deep pool discovery. Perf 4-½"/ft 15,440-530' IP 352 B 1218 CF GOR 3460 C-Pkr. T 1200#.	Deepest flowing production in world at present time. Anticline.
16,246 Dry	Standard of Calif. KCL 20-13	Company	So. Coles Levee Kern	12-27-44 7-31-43	516	11¾"/1188'-7"/10,999'-PBr. 11,050-10,693', 1228-1090' 24-14	75-98 Pcf water base	324	195 No DS	Lo Miocene None	WC. Oil found but not in paying quantities. 2-½"/ft perf. 10,380-660'.	Abd. 1-8-45. Objective Lower Miocene. Anticline.
16,668 Dry	Pacific Western No. 1 Nat'l. Royalties		Miramonte Kern	7-21-47 12-31-45	216	13⅜"/1488-9⅝"/9434 5½"/16,406 top 9504.	Clay base. Max.wt.130#/cuft	175	37 No DS	Lo. Miocene None	WC. Some gas & oil "Wet". 4½"/ft, perf. 12090-11945' and 11910-11720'	Tools twisted off in bottom of hole.
16,727 8,930	Continental Grubb 65-E(301)	Bell & Burden	San Miguelito Ventura	2-24-50 6-14-49	255	16"/916'-9⅝"/8445'-6⅝"/ 14,626'-1207'-4½"/15,775'.	Clay & oil emulsion		57 JFT	Mohnian (Mio) 3rd Grubb Zone	FW. Disc. new sand. 4-½"/ft perf. 9700'-14,480' IP 1311 B 1157 MCF ½" Ck. GOR 882 C Pkr, T 210, SC Pkr, ST 1940# (96 hr.)	Mech. difficulties and tests showing oil in 3rd Grubb Zone prompted final completion at 8742-930'.
17,696 Dry	Standard of Calif. No. 1 Maxwell	Rocky Mountain Drilling Co.	W. Montolvo Ventura	4-24-48 6- 6-47	322	13⅜"/1396'-10,517'-7" frose & cmtd. 11,877'.	Lime Impermex to TD		49 No DS	Repetto Silt None	WC on fault closure with Lower Pliocene (Repetto) formation objective.	Abd. 5-24-48 by California Production Service.
18,734 Dry	Superior Oil No. 1 Limoneira	Company steam rig	Saticoy area Ventura	-49 9- 6-48	188	13⅜"/1979'/1700x-9⅝"/11,209'/ 35x Hi-temp.		172	20 No DS	U. Miocene None	WC. 10-⅜"/ft gun perf. 11,115-8'.	Deepest well in California.
						COLORADO						
15,041 4,930	Mt. Fuel Supply Co. Unit No. 1	Delta Drilling Co.	Hiawatha Moffat	2-26-52 2- 9-50	421	13⅜"/285x-9⅝" 2600x 7"/600x 5½"X line 35x.	Calcium base oil emulsion	276R 46 Dia	56 1 DS	Nugget Lance? 45'	WC. Disc. new sand 108 jet bullets 4885-930' IP 21,000 MCF C 1025, T 200, SC 1720, ST 1750#.	Deepest well in Colorado. Lensing structure. Seismo & geophysical selec.
						FLORIDA						
15,155 Dry	Gulf No. 1 State	Lyle Cashion	Monroe	4- 1-47 11- 7-45	485	24"/147' 175x-20"/576' 600x- 13⅜"/2961'/800x-9⅝"/8002', 600x.	Starch, caustic, Bentonite	142R 2 Dg	175 No DS	Limestone None	WC. Site selected by geophysics. No perf. made.	Deepest well in Florida.
						LOUISIANA						
15,002 14,222	Gulf State Unit No. 26	Company	Lake Hermitage Plaquemines	9- 6-52 1-13-52	238	20"/98'/250x-13⅜"/2469'/1087 x -9⅝"/11,472'/1000x-7"/13,818' /450x-5" X-line/14,263'/39x.	Lime emulsion	98R 4 Dg	108 SD 8 Reed No DS	Sandy shale Miocene 30'	FW. Subsurface geology. Perf. 336-15/32" at 14,178-222' IP 237 B 4620 CF GOR 19,500 C none T 6600# SC none ST 6550#.	Extended field.
15,003 Dry	The Texas Co. No.1StateLse919	Hilburn Drilling Co.	Leeville Lafourche	2- 8-49 4- 9-48	180	13⅜"/2600'/500x-8⅝"/12,004'/ 1000x-5½"/15,003'/400x.				Shale None	WC.	
15,032 Dry	Richardson & Bass Lafourche Rlty 1-K	Rowan Drilling Co.	Lafourche	6-19-51 1-10-51	108	9⅝"/9950'-7"/12,837'/425x-5"/ 14,183'/280x.	Lime base w/diesel oil	69	8W only No DS		WC. Site selected by geophysics. 68 perf. at 11,250'. Tested salt water in 5 zones to 13,997'.	
15,094 14,255	Shell No. 1 J. A. Smith "A"	Company	Weeks Island Iberia	11-26-48 7-11-48	113	16"/120'-10¾"/4564'-7⅝"/ 14,360'-5"/14,974'.			15 No DS	Sand Miocene	FW. 48 perf. at 14,243-55' IP 431 B 472 CF GOR 1095 C none T 2575# Ck 15/64".	
15,140 Dry	Humble No. 2 Cote Blanche	Company	CoteBlancheIs St. Mary	7- 3-47 3- 4-47	121	20"/113'-13⅜"/2694'-9⅝"/ 10,567'.	Lime, alkaline-tannate. Max wt. 11.2#/gal.	44R 29 Dg	85 No DS		WC.	
15,274 Dry	Superior Miami Corp. No. 1-C	Company	CoteBlancheIs St. Mary	3-24-52 6-10-51	288	20"/123'-13⅜"/1920'-9⅝"/ 12,038'-7" Lnr/11,961-13,827'.	Lime Impermex	176R	34 No DS	Miocene None	FW. Salt dome structure.	
15,325 15,230	Shell No. 1 Weeks-Gall Unit3	Company	Weeks Island Iberia	2- 9-52 10-31-51	83	20"/120'-13⅜"/2997'-9⅝"/ 13,632'-4½"/15,321'.		70		Shale Miocene	FW. 160 perf. 15,190-230' IP 663 B 709 CF GOR 1054 T 2700# Ck 15/64".	

WC — Wildcat. FW — Field well. Perf. — Perforations. C — Flowing casing pressure T — Flowing tubing pressure. SC — Shut-in casing pressure. ST — Shut-in tubing pressure. Ck — Choke. † — Deepened. x — Sacks cement.

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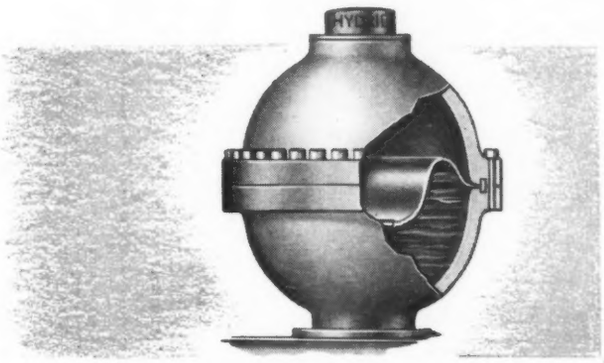

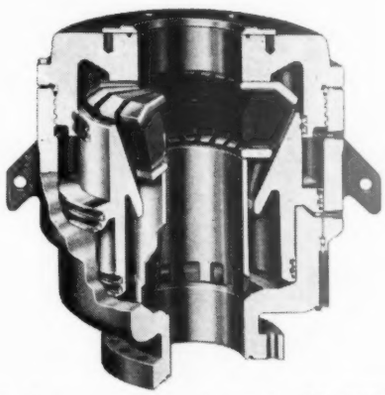

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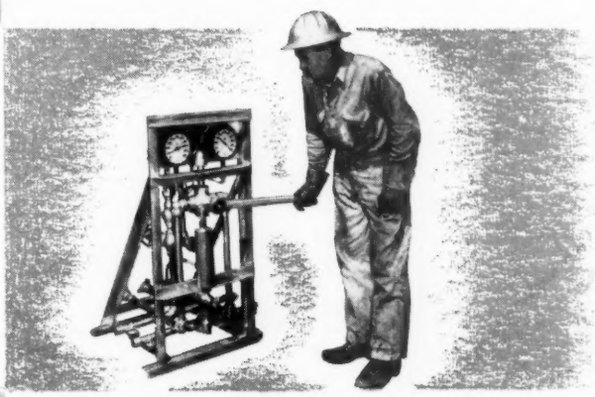
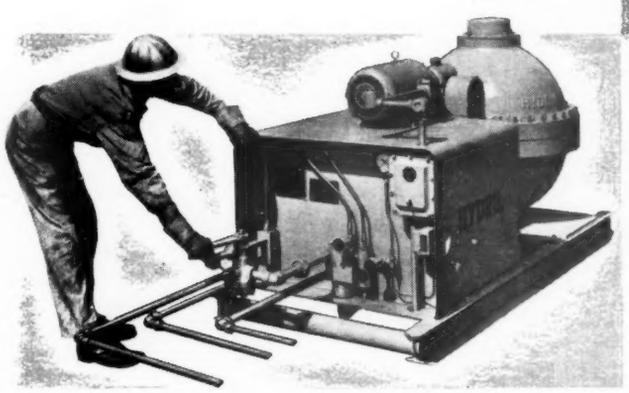


3 then – in any emergency – pull a single lever at **DRILLER'S CONTROL STATION**



4 or at the **REMOTE CONTROL STATION** mounted on the Automatic Pump Accumulator Unit at a safe distance from the well. Controls are foolproof; regardless of which one is operated, the Blowout Preventer will always close...

and STRANGLE THE BLOWOUT *at the* START!

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TABLE 4. DESCRIPTIONS OF WELLS IN THE UNITED STATES DRILLED BELOW 15,000 FT — Continued

TD, ft Prod. depth	Company Well	Drilled by	Field County or parish	Compl't'd Spudded	Drill time, days	Casing and cementing schedule	Mud program	Bits, rock, drag and diamond	Cores Drillstem tests	Deepest form. Producing form., thickness	Perforations, production, pressures, choke, GOR, gravity, etc.	Remarks
						LOUISIANA (Continued)						
15,340 15,238	Shell No. 1 J. A. Smith "B"	Company	Weeks Island Iberia	12-10-51 8-26-51	96	20"/121'-13⅜"/2998'-9⅝"/11,982'-7"/15,249'.		70		Shale Miocene	FW. 128 perf. 15,204-38' IP 692 B 637 CF GOR 920 T 2500# Ck 13/64".	
15,342 15,180	Shell Continental E. T. Weeks No. 1	Gulf Coast Drilling Co.	Weeks Island Iberia	8- 1-52 3-29-52	100	20"/123'-13⅜"/2995'-8⅝"/12,000'-6⅝"/15,339'.		83		Shale Miocene	FW. 160 perf. 15,140-80' IP 573 B 739 CF GOR 1290 C 400# T 1575# Ck 16/64".	
15,343 15,246	Shell Weeks-Gall No. 1	Company	Weeks Island Iberia	11- 5-51 6- 9-51	131	16"/120'-10¾"/4503'-7⅝"/14,557'-5"/15,341'.		110	11 No DS	Shale Miocene	FW. 136 perf. 15,210-46' IP 510 B 537 MCF GOR 1053 T 2225# Ck 12/64".	
15,345 15,246	Shell J. Smith "A" St. Unit "F" No. 1	Company	Weeks Island Iberia	4-11-52 12-30-51	95	20"/118'-13⅜"/2989'-7⅝"/14,550'-5"/15,343'.		70		Shale Miocene	FW. 136 perf. 15,210-46' IP 564 B 571 CF GOR 1012 T 1925# Ck 13/64".	
15,361 15,148	Shell No. 2 Weeks-GallUnit2	Company	Weeks Island Iberia	7-24-50 1-17-50	187	16"/121'-10¾"/4568'-7⅝"/14,590'-5"/15,361'.		136	8 cores No DS	Shale Miocene	FW. 40 perf. 15,138-48' IP 325 B 31° 1516 MCF GOR 4356 Ck 13/64" C none T 2950#.	
15,385 Dry	Texas Co. City of New Orleans Barrow Unit 1	Gulf Coast Drilling Co.	Leeville Lafourche	3-12-51 11- 5-50	104	13⅜"/2538'/500x-9⅝"/11,044'/1000x.				Sand	FW.	
15,470 13,384	Union Producing Buckley-Mahler No. 2	Loffland Bros.	Delarge Terrebonne	9-18-49 3-22-49	170	20"/149'-13⅜"/2970'/1000x-9⅝"/11,237'/1300x-7"/2924'/550x.			5 DS	Miocene Miocene	FW. 18 perf. 13,381-4'-168 perf. 13,350-78'-4 perf. 13,387-9'. IP 792 B 27,000 MCF Ck ⅜" ST 3788#.	Extended field. Deep seated salt dome structure.
15,512 14,144	Texas Co. No. 6 Kling-Walet	Wheless Drilling Co.	Fausse Point Iberia	7-30-51 1-26-51	157	13⅜"/2861'/500x-9⅝"/11,566'/1200x-7"/14,231'/1000x.				Shale Not given	FW. 72 perf. 14,126-44' IP 486 B Ck 19/64" GOR 2120 T 5200#.	New sand discovered in old field.
15,523 13,904	Texas Co. No. 1 Lafourche Basin Levee District	Company	Queen Bess Is. Jefferson	7-23-47 11-17-46		13⅜"/2981'/500x-8⅝"/12,016'/1000x-5½"/13,998'/400x.			1 DS	Hd. sdy. shale & lime Not given	WC. ½" holes 13,879-904' IP 48 B 6,188 MCF Ck ¼" GOR 111,000.	Discovered new productive sand.
15,543 Dry	Texas Co. B-2 Lse 1248, Lake Pelto	Company	Lake Pelto Terrebonne	1- 2-49 6-16-48	192	13⅜"/2506'/500x-8⅝"/12,003'/1000x.				Shale & lime	WC.	
15,549 Dry	Texas Co. No. 6 St.- Atchalafaya Bay	Company	Belle Isle St. Mary	2- 2-48 6-26-47		13⅜"/2495'/750x-8⅝"/10,844'/1600x.				Shale w/sd	WC.	
15,604 Dry	Texas Co. No. 1 St. Lse. 646	Company	Queen Bess Is. Jefferson	9-12-48 3-11-48		13 ⅜"/2024'/500x-8⅝"/12,003'/1000x.				Shale	WC.	
15,732 Dry	Magnolia No. C-1 Ragley Lumber	Company	Hurricane Ck. Beauregard	1-24-52 3-28-51	196	20"/205'/250x-13⅜"/2514'/1000x-9⅝"/9918'/1200x-7"/13,549'/1300x-5"/2429'/175x.		106	65 cores 3 DS	Shale	WC. 406-½" perf.	Geophysical selection.
15,757 Dry	Gulf No. 1 St. Lse. 1773	Rowan Drilling Co.	Timbalier Bay Lafourche	8- 8-52 2-13-52	173	20"/184'/350x-13⅜"/2469'/1100x-9⅝"/11,482'/1000x.	Lime emulsion	106R 5 Dg	109SW 1 Reed	Sdy shale	FW.	Subsurface geology selection.
15,913 14,165	Shell No. 1 Weeks-Gall-St. Unit 1	Company	Weeks Island Iberia	9-20-49 3-31-49	152	16"/120'-10¾"/4502'-7⅝"/14,500'-5"/15,913.		120	24 cores	Shale	WC. 60 perf. 14,150-65'. IP 574 B 651 MCF Ck 11/64" GOR 1134 C none T 2250#.	
15,970 Dry	Shell Williams No. 1	Company	Weeks Island Iberia	9-17-52 3- 6-52	101	20"/120'-13⅜"/3000'-7⅝"/15,086'.		128	21 cores	Shale	WC.	
16,000 Dry	Shell No. 1 St. Lse. 1814	Rowan Drilling Co.	Marsh Island Iberia	7-16-52 9-21-51	300	20"/118'-13⅜"/2513'-9⅝"/11,000'-7"/14,744' 4½"/15,982'.		146	139 cores	Shale	WC.	
16,003 Dry	Texas Co. No. 1 St. Lse. 1605	Company	Blind Bay Plaquemines	10- 1-51 2-28-51	187	13⅜"/2176'/500x-9⅝"/10,272'/1000x-7"/13,970'/500x.					WC.	
16,070 11,986	Richardson & Bass No. 1 Luma Darbonne	So. Prod. Co. to 12,917' then Company	Oberlin Allen	7-23-52 7-28-51	322	9⅝"/11,828'/1700x-7"/12,382'/200x.	Lime base w/ diesel oil	81	100 cores 4 DS	Wilcox Wilcox 10'	WC. 60' jet 11,976-86'. IP 144 B 580 MCF Ck ⅛" GOR 4040 C none T 1725#.	Discovered new field. Geophysics selection.
16,106 Dry	Texas Co. No. 4 St.-Barataria	Company	Queen Bess Is. Jefferson	8-22-48 8-17-47		13⅜"/3017'/500x-8⅝"/12,027'/1000x-5½"/16,106'/750x.			1 DS	Sd & shale None	WC.	
16,237 Dry	Placid No. 1 City of N. Orleans		Lafourche	12-17-50								
16,500 10,176 11,678	Superior Miami Corp. "B"-8	Company	Pecan Lake Vermilion	9-26-51 2-19-51		20"/116'-13⅜"/2006'-9⅝"/12,102'-6⅝"/12,816'-4½"/16,001'.				Miocene Not given	FW. From 10,166-76' IP 310 GOR 714. From 11,666-78' 194 B GOR 562.	Dual completion.
16,648 15,336	Shell No. 1 Gonsoulin-Minvielle	Company	Weeks Island Iberia	8- 3-51 9- 2-50	288	20"/122'-13⅜"/4500'-9⅝"/11,982'-7"/15,634-4½"/16,664'.			107	26 cores	Shale Miocene	FW. 240 perf. 15,296-336'. IP 480 B 552 MCF Ck 19/64" GOR 1150 C none T 2750#.	Deepest producer in Louisiana.

WC — Wildcat. FW — Field well. Perf. — Perforations. IP — Initial production. C — Flowing casing pressure. T — Flowing tubing pressure. SC — Shut-in casing pressure. ST — Shut-in tubing pressure. Ck — Choke x — Sacks Cement

XUM

TABLE 4. DESCRIPTIONS OF WELLS IN THE UNITED STATES DRILLED BELOW 15,000 FT — Continued

TD, ft Prod. depth	Company Well	Drilled by	Field County or parish	Compl't'd Spudded	Drill time, days	Casing and cementing schedule	Mud program	Bits, rock, drag and diamond	Cores Drillstem tests	Deepest form. Producing form., thickness	Perforations, production, pressures, choke, GOR, gravity, etc.	Remarks
	Minvielle											

WC — Wildcat. FW — Field well. Perf. — Perforations. IP — Initial production. C — Flowing casing pressure. T — Flowing tubing pressure. SC — Shut-in casing pressure. ST — Shut-in tubing pressure. Ck — Choke x — Sacks Cement

TABLE 4. DESCRIPTIONS OF WELLS IN THE UNITED STATES DRILLED BELOW 15,000 FT — Continued

TD, ft Prod. depth	Company Well	Drilled by	Field County or parish	Compl't'd Spudded	Drill time, days	Casing and cementing schedule	Mud program	Bits, rock, drag and diamond	Cores Drillstem tests	Deepest form. Producing form., thickness	Perforations, production, pressures, choke, GOR, gravity, etc.	Remarks
LOUISIANA (Continued)												
17,100 9,720	Richardson & Bass Cox Bay Unit 1–33H	Company	Cox Bay Plaquemines	4– 5–52 11–21–51	128	9⅝"/11,372'/1500x.	Lime base w/ caustic and quebracho	81	SW No DS	Miocene? Miocene 70'	FW. 4 jets/ft 9713–20'. IP 195 B 193 MCF Ck⅛" GOR 990 C none T 1700#.	Deep salt dome. Geophysical selection.
18,660 Dry	Magnolia No. D-1 Ragley Lumber	Company	Allen	5– 5–52 6–20–51	231	20"/228'/250x–10¾"/3987'/1200x–7"/13,807'/1060x–5" Lnr. 4894'/3½"/1197'.		120R	58 cores No DS	Shale	WC.	Geophysical selection. Deepest hole in Louisiana.
MISSISSIPPI												
15,730 Dry	Superior No. 1 Cassie Bradford	Company	Forrest	1– 3–47 5–14–46		11¾"/1287'–7⅝"/12,128'–5" lnr /12,066–15,722'.			54 cores 14 DS	L. Cretaceous None	WC.	
16,278	Lion Oil No. 2 Denkman Lbr.	Southern Prod. Co.	Rankin	7–11–52 4–19–51	447	5"/15,760/100x.	Oil emulsion	212R 2Dg	50 cores No DS	Buckner at 14,687' None	WC. Tested intervals 11,200 to 15,600'. T 2850#. ST 4000#	Seismic selection. Produced carbon dioxide. Gas show 15,102—17'.
20,450 Dry	George Vasen No. 1 Fee		Stone									
OKLAHOMA												
15,077 Dry	Phillips et al Flynn No. 1	Howell & Howell	Beckham	6– 9–52 6–26–51	263	16"/143'–9⅝"/3174'–7"/13,433'.				Pa. granite (Deese)	WC.	Gravity work selection.
15,184 Dry	Stanolind No. 1 Briscoe Unit	Kerr-McGee	S.W. Bradley Grady	11–25–48 10– 7–46	527	9⅝"/6960–7"/13,670'–5" Lnr./ 13,645–785'.	Hi viscosity gel chemical, water base	223R 41 core	Wire, line, side wall, diamond 14DS	Arbuckle 15,095 None	WC. Perf. 8839–74', 9261'–316', 9324–70', 9445–80', 9545–75', 10,000–60', 13,645–785'.	Seismic selection.
15,638 Dry	Little Nich Oil No. 4 Glover		Chickasha Grady	8–12–51 7– 5–49						Pennsylvanian	WC. in deeper zones of Chickasha Gas Field.	No information from company. Reported deep gas discovery.
17,094 12,600	Denver Prod. Ref No.1Sch.LandBd.	Company	Caddo	9– 1–48 12–28–46	600	7"/9275/750x–5½"/15,246/500x. 2½"/14,378'.	Aquagel, quebracho, red mud	281R 61 Dia.	72' No DS	Basal Oil Creek Sd.	WC. 150 perf. 12,600-60', 100 perf. 15,400-510'.	Discovered Cogar gas field at 12,600'. Never produced. Sold, to be plugged.
17,823 Dry	Superior Weller No. 51–11	Company	Caddo	8–10–47 4– 4–46	434	13⅜"/1540/1200x–9⅝"/10,240/ 2500x–7"/16,351/650x.		313	14 cores No DS		WC.	Deepest well in world when drilled. Now deepest in Oklahoma.
TEXAS												
15,003 Dry	Magnolia No. 1 G. Doughty	Company	Hidalgo	11–20–51 5–27–51	155	20"/165'/300x–13⅜"/3005'/ 1550x–9⅝"/8982'/800x–7"/ 12,572'/440x.					WC.	Seismic selection.
15,005 Dry	Magnolia No. A-1 McFadden Trust	Company & Vanderbilt Drilling	Jefferson	3–18–52 11–13–51	124	20"/125'/130x–13⅜"/2174'/ 1202x–9⅝"/9436'/500x.		38R 2 Dg	None None		WC.	Geophysical selection.
15,017	Stanolind No. 1 Sarah Hawley	Company	Danbury Brazoria	7– 9–52 11–20–51	196	18"/60'–13⅜"/1346'–9⅝"/9000' –7"/12,350'–5" Lnr./14,684'.	High ph lime base oil emulsion below 9000' natural above	111R 1 Dg	Dia & SW 4 DS	L. Frio (Anomalina) None	WC.	Seismic and subsurface selection.
15,068 10,438	J. S. Abercrombie 20 BRLD Chas. Breen.	Company	Old Ocean Brazoria	8–21–50 3– 2–50	180	20"/82'/327x–13⅜"/3400'/3500x –9⅝"/10,944'/1850x–7"/11,226' /320x.	15# Lime Kembrake below 9500'– natural above	105R	7 cores No DS	Frio Frio, 25'	FW. 84 jet 10,438' IP 179 B 8944 MCF GOR 49,950 C none T 2950# SC none ST 3365#.	Deep-seated salt dome. Site on crest of structure.
15,154 Inj. well	Superior No. 3 So. Tex. Dev. Co.	Company	Lake Creek Montgomery	5– 1–49 7–28–48		20"/80'–13⅜"/1506'–9⅝"/ 11,780'–7"/10,983'.	Kembrake–Impermex			Wilcox None	FW. perf. 11,010–30'. Injection well.	Anticline. Geophysics & subsurface selection.
15,279 Dry	Phillips No. 1 Ada Price	Company	Pecos	2–24–45 6–30–42	682	20"/506'/1270x–13⅜"/1937'/ 1600x–8⅝"/6966'/200x–5½"/ 15,418'/1000x.	Aquagel, barytes, caustic, quebracho, phosphates.		23 cores	Ellenburger None	WC.	Deepest hole in world when drilled. Gravity work selection.
15,301 Dry	Quintana No. 3D So.Tex.Syndicate	Company	McMullen	2–25–45 6–20–44		9⅝"/1523'.	Phosphate	120R	410' No DS	Cretaceous (Georgetown?) None	WC.	Geophysics selection.
15,452 6,159	Humble No. 10 E. F. Milo	Company	Tomball Harris	3–25–46 12–31–44	349	20"/213'–13⅜"/3003'–9⅝"/ 8868'–5½"/10,241'.	Alkaline-tannate-starch max wt. 15.8#/gal.	184R	206 cores 3 DS	Wilcox Cockfield	WC. but completed in field. 78 perf. 6146–59' IP 38 B 3110 CF GOR 82,000 T 2250# ST 2350# Ck. ¼".	
15,468 Dry	Gulf No. 1 Theo Winfield	Olson Drilling Co.	Pecos	10– 4–51 10–19–50	335	13⅜"/719'–9⅝"/4798'–7⅝"/ 8179'.	Salt water to 4800' then fresh water	269R	11 cores 7 DS	Sh & lime (Penn) None	WC.	Subsurface geology and geophysics selection.
16,000 Dry	Texas Co. No. 6 Yturria L & L Co.	Company	Raymondville Willacy	8– 7–47 5–26–46		13⅜"/2128'/1750x–7⅝"/10,624' /1150x.					WC.	

WC — Wildcat. FW — Field well. Perf. — Perforations. IP — Initial production. C — Flowing casing pressure T — Flowing tubing pressure. SC — Shut-in casing pressure. ST — Shut-in tubing pressure. x — Sacks cement. Ck — Choke.

TABLE 4. DESCRIPTIONS OF WELLS IN THE UNITED STATES DRILLED BELOW 15,000 FT — Concluded

TD, ft Prod. depth	Company Well	Drilled by	Field County or parish	Compl'd Spudded	Drill time, days	Casing and cementing schedule	Mud program	Bits, rock, drag and diamond	Cores Drillstem tests	Deepest form. Producing form., thickness	Perforations, production, pressures,* choke, GOR, gravity, etc.	Remarks
						TEXAS (Continued)						
16,347 8,400	Humble No. 1 McWatters	Company	Freestone Freestone	1-20-49 8- 5-47	426	20"/42'–13⅜"/1024'–9⅝"/5104'–5½"/11,797'.	Alkaline-tannate-starch. Max wt. 11.4#/gal.	251R	132 Co. 10 DS	Smackover Pettit	WC. 680 perf. 8315-400' IP 2500 MCF Ck ¼". C 950#/T 1775#.	Discovered new gas field, Freestone.
16,456	Phillips No. 1 Delta Wilson	Delta Gulf	Val Verde							Ellenburger	WC. Temporarily shutdown.	Selection made by magnetometer and gravity work.
16,510 Dry	Phillips No. 1- Washburn A	Company	McMullen	12- 1-51	204	20"/85'/100x–13⅜"/1596'/800x–9⅝"/9181'/750x.	Diesel fuel, mica, Driscose, quadrafos, Quebracho, caustic		28 cores	Cretaceous None	WC.	Seismic selection.
16,655 Dry	Phillips No. 3 F. Schoeps	Company	Brazos	6-15-44	274	20"/81'/75x–13⅜"/3082'/1400x–9⅝"/9656'/800x–5½"/12,030'.	Aquagel, bentonite, barytes, quebracho, Quadrafos		53 cores	L. Cretaceous None	WC.	Deepest well in world when drilled. Millican salt dome. Oil and gas show.
17,906 7,290 8,113	Superior M. S. Welder	Company	Portilla San Patricio	10-10-51 2-18-51	223	13⅜"/1237'–9⅝"/9089'–7"/16,128'.	Lime base oil emulsion	72 R	None None	Eocene (Jackson-Cockfield?) Frio	FW 34 perf. 7280-90'; 33 perf. 8103-9'. IP 310 B & 194 B Ck 16/64 & 11/64". GOR 714 & 862.	Dual completion. Subsurface geology selection on dome structure. Deepest well in Texas.
						WYOMING						
15,172 Dry	Pure Oil Badwater No. 1	Loffland Bros.	Badwater Natrona	6-21-50 6-19-49	367	20"/353'–13⅜"/3223'.	Bentonite, caustic, quebracho	303R	13 cores 1 DS		WC.	Reflection seismograph selection.
16,607 16,102	Pure Oil No. 3 W. Poison Spider	Brinkerhoff Drilling Co.	West Poison Spider, Natrona	1-16-52‡ 3- 6-49	318	7".	Oil emulsion	236R	21 cores 2 DS	Morrison Morrison	WC. 1056 perf. 14,595-15,160' & 972 perf. 15,932-16,094'. IP 57 B 442 MCF GOR 7764 C Pkr T 50# SC Pkr ST 3100#.	Deepest production in world. Reflection seismic selection. Antiline.
20,521 Dry	Superior Oil Pacific Crk. No. 1	Dyer & Rice to 9881 then Co. rig	Sublette	8-18-49 7-13-47	453△	13⅜"/1000'/750x–9⅝"/9929'/1500x–7"/19,785'/1000x.		109□ 211○	24 cores 19 DS	U. Cretaceous None	WC.	Deepest well in world.

‡ — Temp. abandoned at TD 10,128' 6-19-49 to 8-31-51. △ — Temp. abd. 11-11-47 to 7-23-48. □ — Contractor. ○ — Company.

TABLE 5. Location and averages of wells below 15,000 feet.

State	Number wells	WC	FW	Drilltime, avg. days	avg. Bits,	Mud costs, avg.	Well costs, avg.
Alabama	1	1	..	225	186	.....	.....
California	9	7	2	302	224	$70,000	$492,000
Colorado	1	1	..	420	322	.....	.....
Florida	1	1	..	485	144	.....	.....
Louisiana	32	16	16	180	102	52,000	503,000
Mississippi	3	3	..	306	237	.....	.....
Oklahoma	5	5	..	456	306	35,000	626,000
Texas	15	11	4	283	159	73,000	588,000
Wyoming	3	3	..	379	286	.....	.....
Total	70	48	22	258	163	$59,000	$550,000

in eight years of rising costs and no definite relation was found between year drilled and costs.

These are the years in which 15,000-ft wells were drilled: 1938, 1; 1945, 4; 1946, 1; 1947, 8; 1948, 7; 1949, 10; 1950, 4; 1951, 14; 1952, 21.

Drilling Time

One thing that pushes costs up is the drilling time. The 70 wells studied had an average of 258 days' drilling time alone. This drilling time runs from a low of 83 days to 682 days in the United States and goes still higher in Venezuela. Taking a labor estimate of $1200 a day for a drilling crew, this drilling time quickly runs up costs.

A Shell field well in Weeks Island drilled to 15,325 ft in 83 days seems to be the record time for that depth, and it is an important record. Phillips was on location at the Ada Price No. 1, Pecos, Texas, from June, 1942, to February, 1945, and counted 682 drilling days. This was during World War II, however, and the operation was plagued by shortages and make-do equipment.

Bits

Bits account for another big item in deep drilling. An average of 163 bits was used on the 70 wells below 15,000 ft. These were almost all rock bits although diamond bits were used and are coming more and more into the operation. In fact, without the new stronger bits it is doubftul if there would be 70 holes below 15,000 ft.

The famous Gulf McElroy in West Texas, first well to go below 12,000 ft in 1935, used 718 bits and 247 core heads.

In 1950 an average number of bits used on wells 12,000 ft and deeper was 107, so the extra 3000 ft in this division of 15,000 ft wells requires an average of 56 more bits; this is a third more drilling bits for the last fifth of the hole.

Drilling Fluid

Drilling mud has been another aid to deep drilling and has, at the same time, added to the cost. About average was $59,000 per 15,000-ft well. Surprisingly enough mud costs are lower in comparison with costs of earlier years for 12,000-ft wells. So there is a pretty clear indication that the last few years have seen a remarkable advance in mud engineering.

Two articles in this issue discuss at greater length the importance of mud in deep drilling. (Pages B-51 and B-78.)

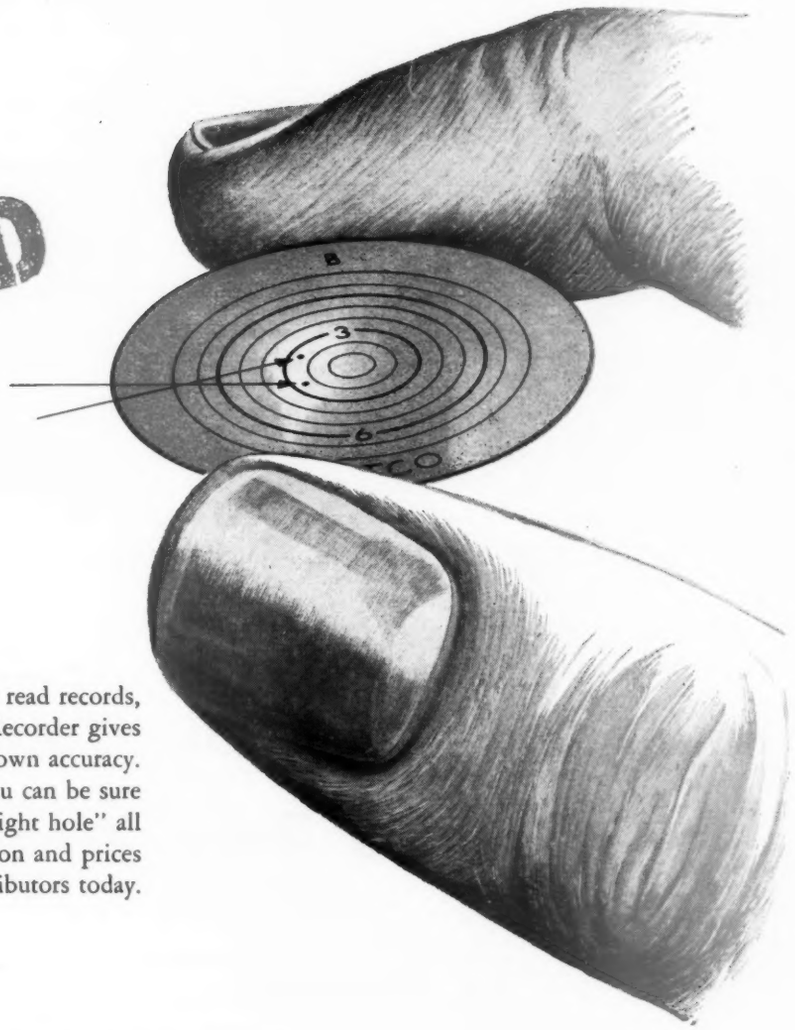
Advantages

In his article in this issue (Page B-7) G. Frederick Shepherd has made a good case for drilling to basement on first exploring a structure, whether paying oil and gas sands are penetrated or not. Stopping at the first production certainly leaves much information that may be vital in efficient development of a field. Despite the high cost, a deep well may be the key to economic decision even if it does not open new reservoirs.

The fact that 23 operators in the United States and two in Venezuela have risked large sums to drill below 15,000 ft demonstrates a strong belief in the potential of greater depths. Their pioneering spirit has contributed invaluable information not only to their own geological and engineering departments but to the whole industry. It will be easier and safer and cheaper for those who follow them. The equipment manufacturers and service companies are already at work on problems of deep drilling that will make 15,000-ft wells as commonplace in another decade or so as 10,000-ft wells are now.

If demand and prices of petroleum rise there will be an acceleration of deep drilling projects as there has been in the past. It took a lot of drilling over vast areas before the giant East Texas field was found. It would hardly be surprising if it takes more to come upon one like it three miles down. * * *

VERIFIED



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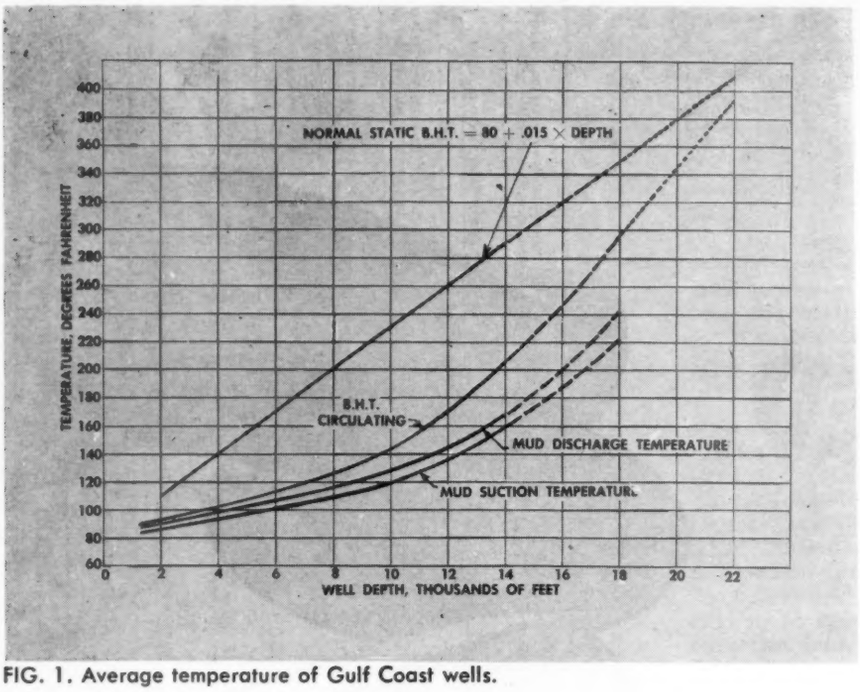

FIG. 1. Average temperature of Gulf Coast wells.

Equipment, Materials, Tools for Cementing Deep Wells

PHIL MONTGOMERY

GREAT emphasis has been placed in recent years on equipment used in cementing deep wells, regular production tests below 10,000 ft to 15,000 ft, and wildcat explorations from 15,000 to 20,000 ft. Many items can be used by the operator working out the problem of cementing these deep wells from a standpoint of equipment, materials, and tools already field tested and in use at the present time that are built to cover these deeper ranges.

Under equipment, plugs, plug containers, centralizers, wall cleaning devices, and pumps have been developed.

Under materials, cement retarders, pozzolan cements, modified cement, and other special additives have been developed.

Under tools, multiple stage cementing, both two-stage and three-stage, formation packer shoe, liner devices, drillable retainers, hydraulic removable cementer, caliper survey, and temperature survey equipment have been developed.

All of these items are built and tested to cover from 10,000 to 20,000 ft depth ranges and are being used successfully below 10,000 ft in the field. The equipment necessary to cement deep wells requires that it stand up under temperatures of 200 to 400 F, often at terrific working and static pressures.

Fig. 1 is taken from data supplied by the API special committee on oil well cements. The average of data taken from various fields along the Gulf Coast are shown giving the normal bottom hole temperature and the bottom hole circulating temperature up to a depth of 14,000 ft.[1] Information from the API records has been extended on actual data to show what may be expected from 14,000 to 18,000 ft. These data have been further extended theoretically from 18,000 to 22,000 ft to show expected bottom hole temperature and bottom hole circulating temperature on wells in the Gulf Coast area. These are average values and specific wells may vary considerably from these figures.[2]

Test pressures of this deep well equipment are extremely high, especially on tools used for squeeze remedial work. Other types of equipment take into consideration the strength of the casing as the minimum.

EXCLUSIVE

Field conditions vary in different sections of the country and in different fields all over the world. In the planning of a successful job of this type, the using of special equipment, materials and tools is required.

Equipment

Plugs. The type 5 WT (five-wiper top) cementing plugs, which are now in general use, have a construction of cast aluminum and molded rubber. (Fig. 2.) The top plug has several characteristics that are very important in cementing deep wells: (1) It wipes the casing free of mud and cement as it passes through, (2) fully separates the mud from the cement within the casing, and (3) makes a complete shut-off of flow when it reaches the float collar and does so under all pressure and velocity conditions. This type of top plug has been used successfully below 19,000 ft.

The 5 WB (five-wiper bottom) cementing plug is a construction of cast aluminum and molded rubber with a rupturable diaphragm to allow the passage of the slurry when it hits the floating equipment. This bottom plug, as it passes down the pipe, fully separates cement from the mud within the casing.

These cementing plugs, both top and bottom, are shown in Fig. 3. The cutaway section of both plugs shows that the bottom end of each is shaped to fit correctly in the area of all standard makes of floating equipment and, when run as a team, the top plug fits perfectly into the top of the bottom plug. It can also be noted that the metal part of the top plug is so stationed that it serves as a positive reinforcement when landed on either the bottom plug or floating equipment. The use of the top and bottom plugs together has materially increased the success of casing cementing jobs. It has been found that the use of the top and bottom plugs is also very important in that it frequently allows the well owner to go back in to run a

The Author

Phil Montgomery recently returned to Halliburton Oil Well Cementing Company of Duncan, Oklahoma, after spending a year with Petroleum Administration for Defense in Washington. Manager of Halliburton's Research and Development before PAD service, he has been named to a new position with Halliburton, that of technical coordinator for cementing services, and is attached to the staff of William D. Owsley, vice president for engineering advice to management.

Montgomery is a graduate of the University of Oklahoma where he majored in engineering. He has been with Halliburton for the last 20 years, the first 10 as a field engineer and the second 10 in supervisory engineering posts at the company's Duncan headquarters.

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Simplicity of design and completely automatic operation make the "H1" exceedingly easy-running, easy-pulling — it may even be run upside down without the slightest effect on its operation. Case hardened piston slips in Monel inserts assure positive action and maximum corrosion resistance. Piston slips operate independently and provide equal distribution of gripping force against the casing I.D. with no localized high pressure areas. This, coupled with a limited piston slip stroke, positively precludes swaging or damaging casing in any way. Piston slip gripping area is 100% effective in any weight casing within the anchor size range. "H1" anchors are individually tested and will hold any pressure the tubing will stand.

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FIG. 2. Type five-wiper top and bottom cementing plugs.

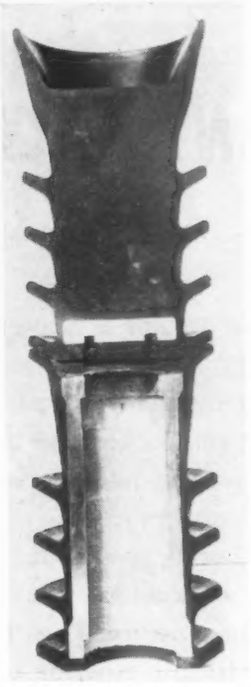

FIG. 3. Cut-away section of five-wiper top and bottom cementing plugs showing how the top plug fits into the top of the bottom plug.

temperature survey and other wire line work immediately after the cementing job has been completed, due to the fact that it is not usually necessary to go back with tools and clean out on top of the cementing plug. This is often a saving and proves the effectiveness of this system of plugs.[3]

Plug Containers. Occasionally well owners are reluctant to open the top of the casing once circulation has been established after casing has landed. This reluctance is usually due to the possibility of the pipe freezing when circulation is stopped for any reason. The danger of the pipe freezing is much greater in some areas than in others. Drillers and operators can usually predict an imminent hazard ahead of time. When this hazard is imminent it is desirable that every precaution be taken to prevent any stoppage of circulation. Insofar as surface cementing equipment is concerned, the double plug type container meets all the requirements. Such plug containers are designed so that the bottom and top plugs can be released at the proper time without opening the casing. See Fig. 4.

With the plugs now available, which are both highly efficient and safe to run, and the cementing equipment especially built to handle these plugs without opening the casing during the entire cementing operation, it is possible to utilize the two-plug method in any area. The combination use of the above-mentioned plugs and plug containers has been successfully used in a great many areas.[4]

A continuous type plug container, shown in Figs. 5 and 6, contains two plugs and can be used in the same way as the double-plug container; however, it is built to withstand higher pressures, especially in the larger sizes. There are areas where use of this equipment is desirable and it is in common use by the industry in these areas. The head is designed for use with the five wiper type rubber cementing plugs and holds both a top and a bottom plug, each of which is released separately by turning a plug release handle 1¼ turns. The plugs are loaded easily by removing the quick change cap and simply dropping the plugs into the body after setting the plug support arms. A truly continuous operation is provided, as both the bottom and top plugs can be dropped while pumping into the same inlet without varying the rate of pumping. This is accomplished by pumping into the head near the top of the bottom plug so that it is carried down by the fluid. When the top plug is released, it is pushed down into the fluid stream by a spring attached to the quick change cap.

The plug container body is con-

FIG. 4. Plug container, double plug type.

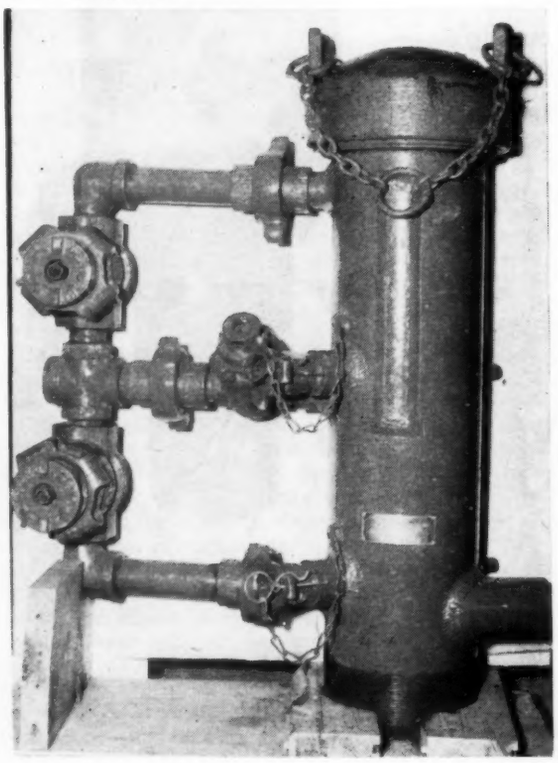

FIG. 5. Plug container, double plug continuous type. Lever type indicator showing that plug has not been released.

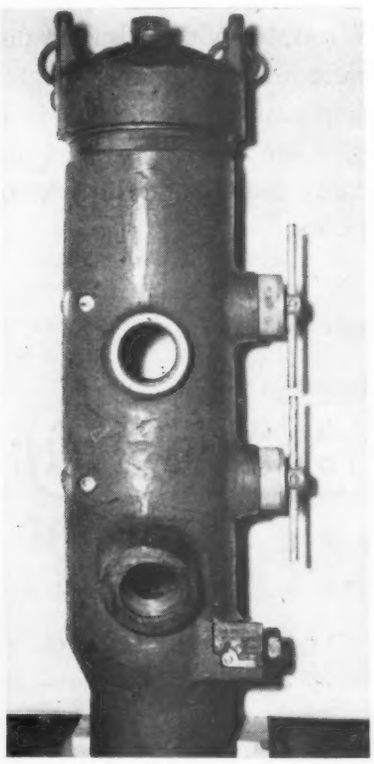

FIG. 6. Plug container, double plug continuous type. Lever type indicator showing that plug has been released and moved out of plug container.

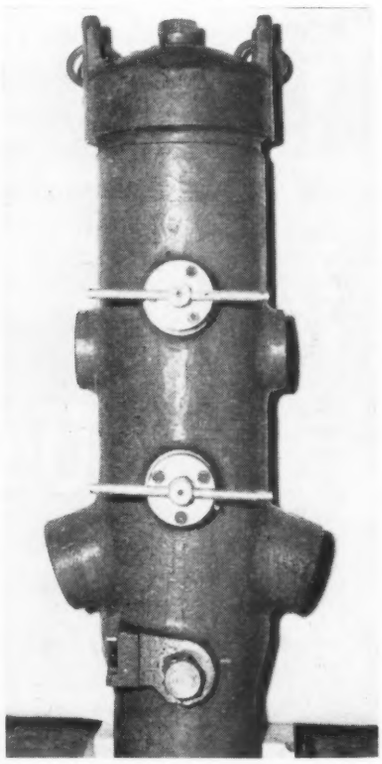

FIG. 7. T-10 pump mounted on six-wheel drive cementing unit.

FIG. 8. Twin T-10 pumps mounted on trailer cementing unit.

structed with longitudinal internal ribs which provide a large by-pass area around the plugs. Two 3-in. inlets placed 180 deg apart are provided for the cementing pumps and two more 3-in. inlets are situated below the bottom plug for circulating before the bottom plug is dropped. The unit is equipped with a lever type indicator which indicates the passage of the plugs. The body is designed for an internal bursting pressure of 18,000 psi and each unit is pressure tested to 8000 psi. As the continuous head does not require a manifold, its total weight compares favorably with that of standard plug containers, in spite of its increased strength and larger by-pass area.

It is believed that this double plug continuous head will fulfill a long standing need due to its characteristic, which may be summarized as follows:

(1) Withstands high pressures.
(2) Provides indication when the plug passes into the casing.
(3) Requires no elaborate manifold.
(4) Prevents fouling of release mechanism, should fluid be pumped in above the plugs before they are released, because of large by-pass area.
(5) Simple in operation and provides easy loading of the plugs.
(6) Provides continuous operation.

In planning a cement job, the plug containers and plugs are well worth taking into consideration and each have their place in different areas due to different field conditions.[5]

Centralizers. Centralizers are run with and without the two types of wall cleaning devices. Considerable work has been done to gather data on the proper placing of centralizers and the number of centralizers necessary for various casing loads against the wall of the hole.[6]

Wall Cleaning Devices. The oil industry is using at the present time wall cleaning devices that fall under two classifications: The type in which the casing is reciprocated and the type in which the casing is rotated.

By using the rotating type wall cleaning device the casing is placed at the proper casing point and there is no reciprocating action, but all the action is of a rotating nature. This keeps the bottom of the pipe at the casing point at all times. Thus, during the cementing job, the casing is at bottom at the correct depth. This is particularly important in deep well cementing.

Pumps. Cementing of deep oil wells has a pronounced affect on the pumping equipment to be used. As depths become greater, pressure requirements for cementing increase and greater speed of mixing of slurry and handling of displacement fluid becomes more important. A special pump was developed and has been constantly improved on since it was first placed in the field. This pump is a triplex, outside packed plunger, single acting type, 10-in. stroke and is used with two different types of fluid ends having plungers from 4-in. to 6-in. in diameter. In the 4-in. size it is capable of pumping in excess of 12,000 lb. While the 6-in. is capable of handling fluid at slightly more than 750 bbl per hour or about 55 sacks of cement per minute. This pump has been used in practically all parts of the oil country and has been mounted on several different types of cementing units. Fig. 7 shows one of the latest installations. It is also mounted on a trailer unit, as shown in Figs. 8 and 9.

Several new pumps are under devel-

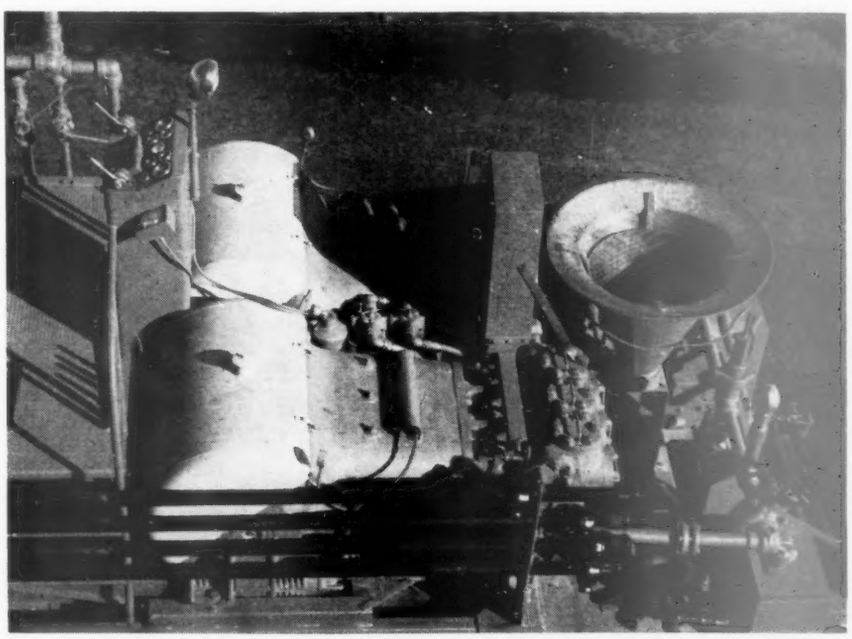

FIG. 9. Top view of Twin T-10 pumps mounted on trailer cementing unit.

opment — pointed toward even greater flexibility and strength. A continuous research program on pumping equipment is being maintained.

There is at the present time under field test a special trailer unit using a dual plunger pump. Each pump has two fluid ends — one for volume and one for pressure. From the field test that this equipment has been through it shows indications of being a further improvement in equipment for special jobs required in deep well cementing.[7]

The present arrangements of pumps usually will exceed the volume and pressure required on present day oil well cementing even to the deepest depths, and although there is an extensive research program at the present time to build improvements to this pump and other types of pumps, the ones mentioned are adequate for any well depths and temperature conditions that have been encountered to date.

Materials

Cement Retarders. A new retarding agent has been developed that can be used both with portland cement and oil well slow setting cements. Tests of this chemical with oil well slow setting cements show that it can be used at a temperature of 400 F with a three-hour pumpability period. This material is in a powdered form that can be blended with a cement and the mixture then hauled to the field in bulk convoys. With the use of modern bulk cement blending equipment, cement can be compounded with closely controlled materials making it possible to prepare a cement that fits practically any given well condition. This is illustrated in the following table showing the retarding action produced in various cements for deep well cementing.

Retarding Action.

Cement	Water gallons per sack	Per cent retarder	Per cent bentonite	Simulated well depths*	Thickening time hours—minutes
ASTM Type 1	5.2	.0	0	10,000	1:38
ASTM Type 1	5.2	.3	0	10,000	1:55
ASTM Type 1	5.2	.4	0	10,000	3:42
ASTM Type 1	5.2	.0	0	14,000	1:10
ASTM Type 1	5.2	.4	0	14,000	2:33
ASTM Type 1	5.2	.5	0	14,000	3:28
ASTM Type 1	5.2	.6	0	14,000	5:26
Retarted oil well type cement	5.9	.0	4	20,000	1:00
Retarted oil well type cement	5.9	.8	4	20,000	1:55
Retarted oil well type cement	5.9	1.0	4	20,000	2:15
Retarted oil well type cement	5.9	1.2	4	20,000	2:15+
Retarted oil well type cement	5.9	1.5	4	20,000	2:45+
Pozzolan cement 50–50 ASTM Type 1 cement and Pozzolan.	5.6†	.0	2	10,000	1:22
Pozzolan cement 50–50 ASTM Type 1 cement and Pozzolan.	5.6	.3	2	10,000	2:17
Pozzolan cement 50–50 ASTM Type 1 cement and Pozzolan.	5.6	.5	2	14,000	2:01
Pozzolan cement 50–50 slow setting cement and Pozzolan....	5.1†	.0	2	14,000	1:06
Pozzolan cement 50–50 slow setting cement and Pozzolan....	5.1	.5	2	14,000	3:15+
Pozzolan cement 50–50 slow setting cement and Pozzolan....	5.1	.5	2	16,000	1:49
Pozzolan cement 50–50 slow setting cement and Pozzolan....	5.1	.8	2	16,000	2:14
Pozzolan cement 50–50 slow setting cement and Pozzolan....	5.1	1.0	2	18,000	1:45
Pozzolan cement 50–50 slow setting cement and Pozzolan....	5.1	1.2	2	18,000	1:47
Pozzolan cement 50–50 slow setting cement and Pozzolan....	5.1	1.5	2	18,000	1:47

* Well depths simulated according to API Code No. 32.
† Water ratio is given in gallons per equivalent sacks which is 82 lb for the 50–50 blend.

Pozzolan-cement. A new type of cementing material containing a mixture of pozzolans is now finding wide application by the oil industry.[8] This material has a number of characteristics which offer improvements over straight portland cement.[9] For oil well cementing, pozzolan-cement can be used with various flake and granular additives, which aid in bridging and sealing thief formations to obtain high columns necessary in oil well cementing.[10, 11, 12] As shown in accompanying table the pozzolan-cement mixture can be used in high temperature wells.

Modified Low-strength Cement. A modified cementing composition may be prepared from either high early strength or normal portland cements by the addition of bentonite clay and a suitable agent for dispersing and controlling the set slurry.[13] Slurries of this composition have the advantage of light weight which allows for higher placement behind casing in some areas. Also such low strength cements have better gun perforating qualities.[14]

Additives for Use in Cements. With the use of modern bulk cement blending equipment, it is possible to properly proportion different types of additives to oil well cements. Additives in common use today include:

For lost circulation materials.
(1) Cellophane flakes
(2) Mica flakes
(3) Expanded perlite
(4) Granulated nut shells[15]
(5) Shredded fibrous materials

Cement Accelerator.
(1) Calcium chloride
(2) Sodium chloride

Retarders and Dispersants.
(1) HR-4
(2) Kembreak
(3) Lignisite

Bulk Additives.
(1) Bentonite
(2) Pozzolans
(3) Expanded perlite

All of these materials can be blended in any practical proportion with bulk cements and delivered to the well in convoy units.

Tools

Multiple Stage Cementing Using Two-stage Method. Multiple stage cementing using the two-stage method makes it possible to do a cement job at the bottom through the casing shoe with the second cementing job being placed through the two-stage tool at any predetermined point in the casing. These cement jobs can be done as a continuous operation, or it is possible to do the bottom job, open the tool and circulate before cementing through the two-stage tool.

A few of the advantages of this type of arrangement are: Full depth cementing, cementing off formations at any point, reducing pump pressure, and preventing loss of cementing slurry to thieving formations. Many of these tools have been run both in this country and in foreign operations in many different fields to overcome special problems at all depths. After the cement job has been completed on the two-stage tool, a special plug closes the tool by operating a built-in sleeve in the tool. Different types of plugs are built to be used in the two-stage tool to suit various types of operations.

Multiple Stage Cementing Using Three-stage Method. By using this arrangement it is possible to do a job through the casing shoe and two other cementing jobs at predetermined points by placing two multiple stage cementers, a two-stage, and three-stage tool, at predetermined points in the casing. The first two jobs are run as a continuous operation and then a bomb type plug is used to open the three-stage tool to do the third cementing job.

It is also possible to do the first job through the casing shoe, open the first tool, circulate, allowing the cement to set in the first job, and then do the job through the first tool. And it is possible to go ahead and open the second tool and allow the cement to set that has been placed through the first tool before doing the cement job on the last multiple stage cementer for the third stage. This arrangement requires special opening and closing plugs and tool sleeves in order to do three-stage cementing. The three-stage cementing method has been run successfully in the field and has been used in working out special field problems which arise.[16]

Packer Shoes. There are in common use at the present time float shoes equipped with a packer set by pump pressure. After the packer is set, circulation takes place through the ports above the packer. This allows the operator to do a cement job above the packer and to hold the pressure off the formations below the packer.

This type equipment can also be obtained in collar form and run in the casing string with a perforated liner below doing the cement job above the perforated liner and above the packer.

It is also possible to combine this type of packer shoe with the multiple stage cementing tools, using a special tripping device to set the packer shoe.

Liner Jobs. Liner jobs are run in all depths of wells using a special tool on the end of drill pipe. In most cases the liners are set from the bottom of the hole with an overlap back up into the casing string above. The sizes of these liners vary according to the casing string through which they are to be run. In some cases more than one liner is run in the same well. This is due to deepening operations which were not considered on the original casing pro-

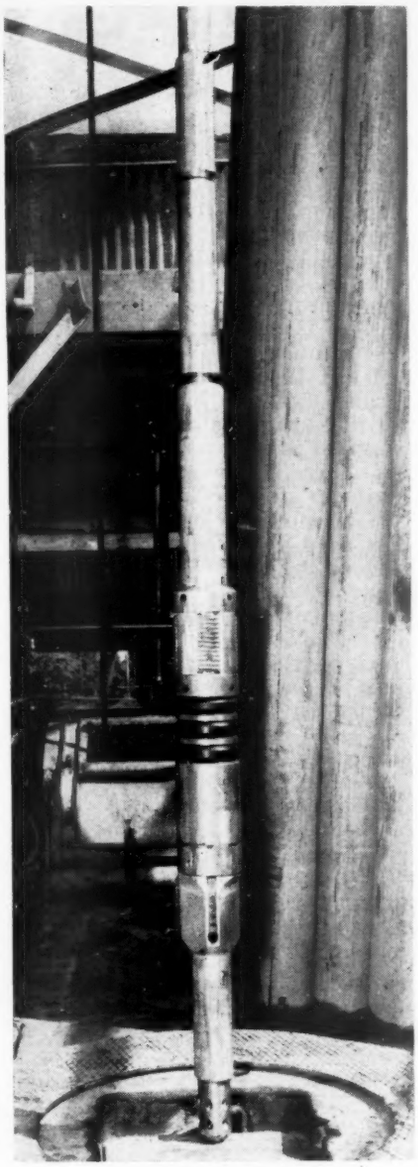

FIG. 10. Hydraulically operated retrievable cementing tool.

gram or in exploratory holes where it is not preferred to set a complete string of pipe to the surface. Several liner tools of excellent design for deep well cementing are available today.

Drillable Cement Retainers. Drillable cast iron, aluminum, and magnesium cement retainers are used for squeeze work and remedial work under practically all types of field conditions. This equipment is built for the gaskets and the packers to withstand extremely high temperature and pressures greatly in excess of what is commonly encountered at the present time. Their use has become generally accepted routine practice to fit a wide variety of well conditions.

Hydraulically Operated Retrievable Cementing Tools. There is now in use a hydraulically operated tool designed to perform efficiently, under the highest pressures and the most severe conditions, the many and varied operations encountered in "squeezing" cement, acid, and other materials. The hydraulically operated retrievable cementing tool is especially well suited for locating casing leaks. (Fig. 10.) Some of the unique operating features of the tool are:

(1) Since the tool is so constructed that there is no opening to the casing or well bore while the slips and packer rubbers are being set by hydraulic pressure, the tubing is automatically tested while setting the packer, thereby eliminating the need for using a ball or tubing plug. The tubing may be tested to 10,000 psi if desired.

(2) After the tool is set, the packer will hold pressure from either above or below without putting a strain on the tubing. The slips are designed to prevent the packer moving in either direction and pressure applied either above or below the packer tends to make the slips set more firmly. The tool is designed to hold up to 10,000 psi differential pressure below the packer and 5000 psi differential pressure above the packer.

(3) The tool is not dependent upon the pulling capacity of the rig or the amount of tubing weight available for its setting force, since both the slips and packer rubbers are set firmly with fluid pressure. This makes it possible to use harder, more durable packer rubbers, which are less affected by temperature or pressure.

(4) The packer does not have to be pulled loose, as it is unseated by merely picking up on the tubing with the pressure equalized at the packer point.

(5) The spring loaded safety joint allows the tool to be rotated out of the hole. Rotating out of the hole automatically opens the circulating valve so that the tubing is pulled dry.

(6) The ring type packer rubbers, being smaller than the adjacent metal parts of the tool, are well protected when entering a liner or other restriction.

(7) The circulating valve can be opened at any time in case of an emergency.

(8) The spring loaded right hand safety joint may be disengaged by pulling 20,000 lb or more and rotating eight turns to the right. All parts below the safety joint are made of drillable material. The safety joint will not be disengaged unless a pull of 20,000 lb or more and right hand rotation are applied simultaneously.

(9) The packer can be set as many times as desired without coming out of the hole.

(10) The operation of the tool requires no complicated drill stem manipulation. Complete operation for any job consists of only up and down movement of the tubing after the circulating valve is turned to the right to remove the lugs from the locked open position.

(11) The tool can be run in the hole rapidly without tubing overflow. Also, the design of the friction drag blocks allows the tool to be started in the hole without difficulty.

(12) Sand bridges encountered while going in the hole can be washed out by reverse circulation.

Caliper and Temperature Surveys.

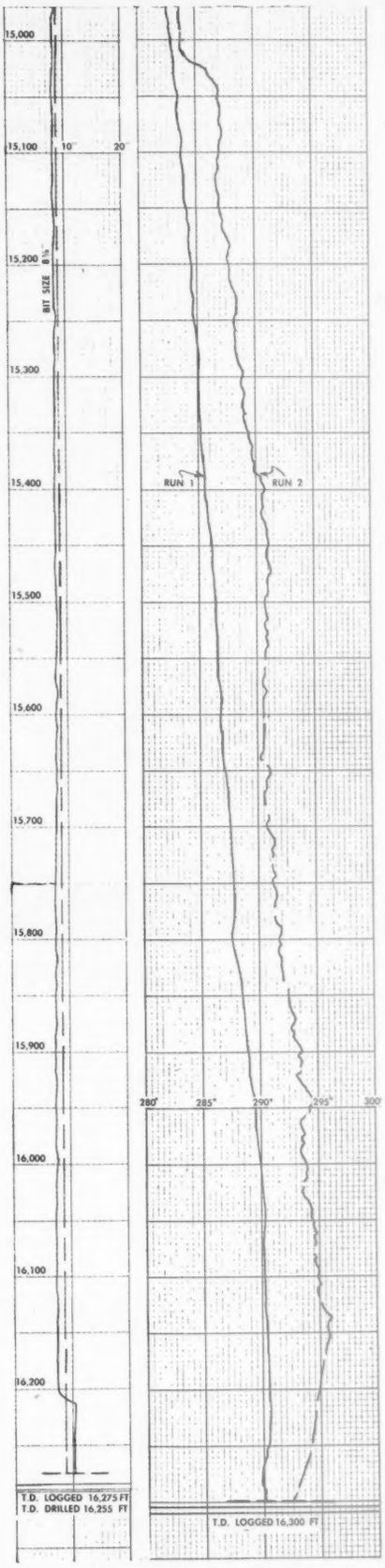

FIG. 11. Left, portion of caliper survey made at a depth of 16,275 ft.

FIG. 12. Right, portion of a temperature survey made at a depth of 16,300 ft. There are 2 runs shown on this log. First run was made 8 hours after circulation was stopped. The second run was made 4 hours after the first run.

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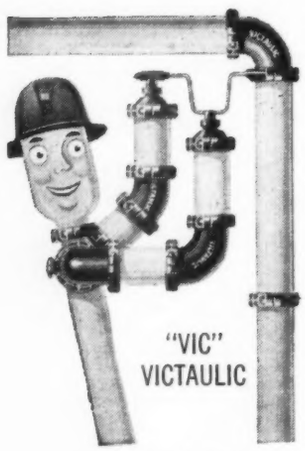

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Caliper tools have become a very valuable aid in well completions. Much data can be obtained from running a caliper tool, which is of great value in planning a cementing job. Fig. 11 shows portion of a caliper log made at a depth of 16,275 ft. This type of caliper tool is run at practically all depths.

Sensitive temperature tools are run to determine the cement top behind the casing. This is of particular importance when sealing off corrosive waters. Temperature surveys run in open hole are often of great assistance in planning the cementing job and completing the well. Fig. 12 shows a portion of a temperature log run at 16,500 ft. There are two runs shown on this log. The first run made eight hours after circulation was stopped. The second run was made four hours after the first run.

In planning the primary cementing of a deep well, the necessary tools, material, and equipment that are needed should be considered with the following items pertaining to the well itself: The bore hole, drilling fluid, casing, drilling rig operations, and the coordinating of the personnel between the well owner and the service company. With these facts taken into consideration, a much more efficient job can be planned.[17]

Attention should be given the mud treating chemicals used in the well and the effect they may have on the oil well cement that is to be used.[18] Especially where highly chemically treated muds are being used at great depths there are possibilities of detrimental action on the cement slurry being placed.

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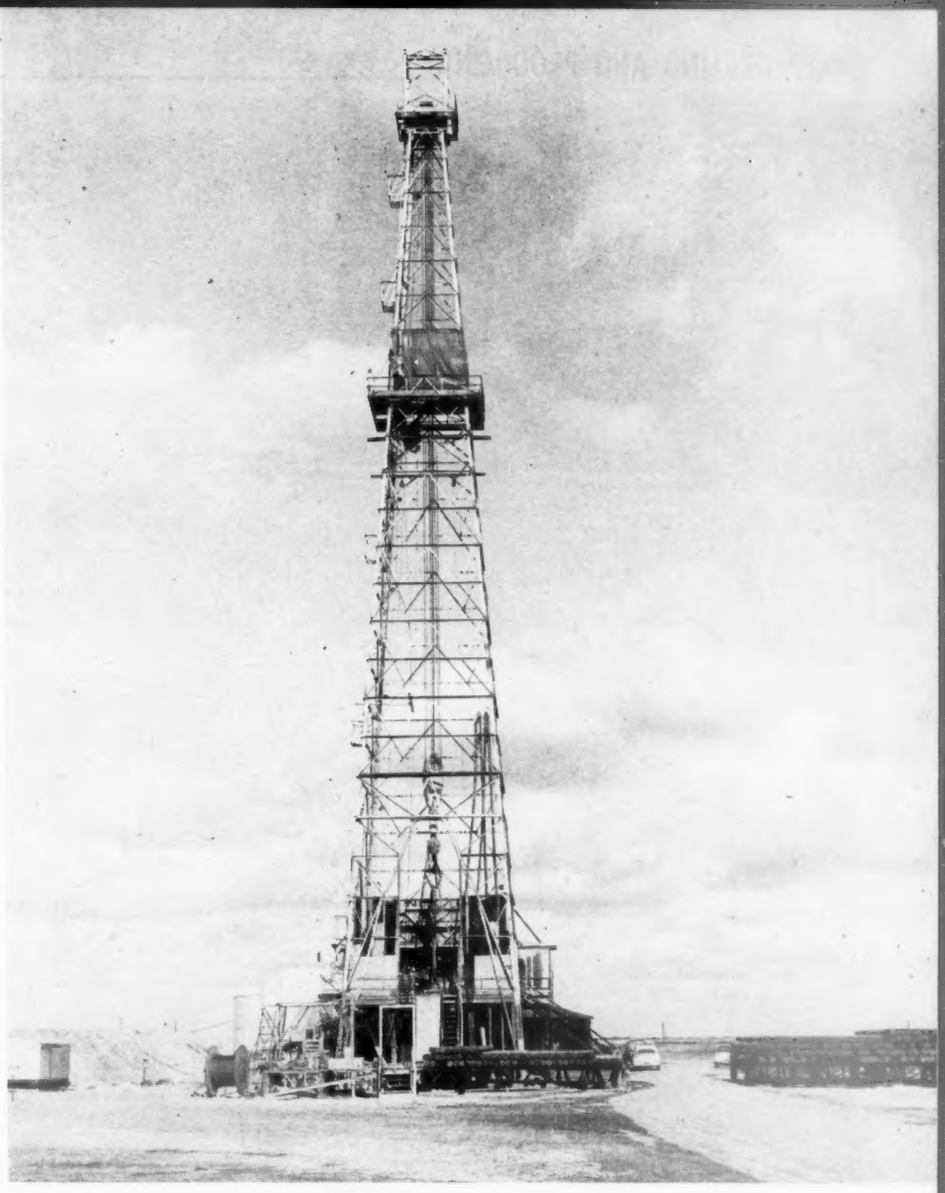


The Ohio Oil Company's KCL A No. 72-4 in the Paloma field southwest of Bakersfield, California.

P 400.

Deepest Active Test in California Seeks Record

Ohio Oil Company's well at Bakersfield challenges record depths for drilling and for production

WILLIAM RINTOUL

ONE of the most ambitious test wells ever planned for California today is heading into unexplored strata more than three miles below the surface of the Paloma field, 15 miles southwest of Bakersfield in Kern County.

The Ohio Oil Company is backing the test well, which in early December had reached a depth of 16,495 ft. According to the program for the test well, penetration will proceed to a total depth of between 18,000-22,000 ft. Principal objective is the Eocene zone, a highly productive pay horizon in many of the Southern San Joaquin Valley fields in California. In the absence of other deep tests in the Paloma field, it is pretty much of a question as to where the Eocene will be found.

Designated at KCL A No. 72-4, the deep test is located on Section 4—T 32S —R 26E. It is on land leased from Kern County Land Company in the south central portion of the 12-year-old Paloma field, where 97 wells produce an average of 8400 bbl-per-day of 48-60 gravity crude oil from depths of 10,650-11,-440 ft.

One of the first considerations when the deep test was approved was to lease the open land that might be affected by a deep discovery. Several weeks before spudding the test well on October 23, 1951, The Ohio Oil Company increased its already considerable holdings in the Paloma district through lease of an additional 2598 acres from Kern County Land Company.

Equipment assembled for the projected drilling job attested to the serious determination with which The Ohio Oil Company is pursuing its Paloma prospect. If there is anything to that saying about the third time proving the charm, the operator may expect to enjoy success with the Paloma deep test.

A company rig is being used for the drilling job and the current project makes the third start in five years for the powerful rotary. Previously it was used for a deep test in the West Branch field of Ogemaw County, Michigan, and a 13,818-ft duster on the Mitchell lease near Arvin in Kern County.

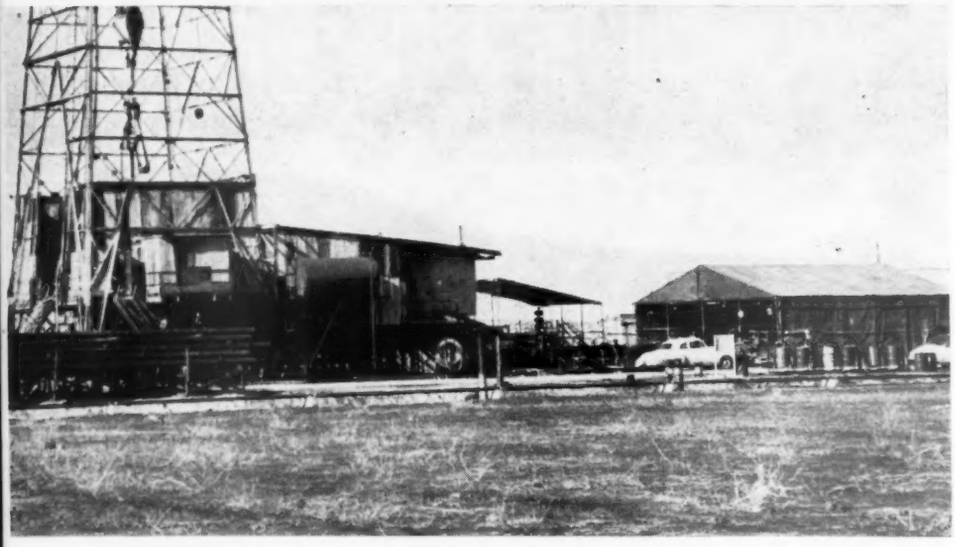
Rigging-up required about two weeks at the Paloma location and proved to be considerably less trying than the original rig-up job in Michigan. Much of the Michigan work was done in temperatures as low as 33 deg below zero. In Michigan's sub-zero weather it was necessary to lay more than one mile of steam coils and cover them with sheet iron to thaw out the ground for excavation.

A 178-ft Lee C. Moore steel derrick with 36-ft base and 15-ft substructure marks the drill site for miles around in the flat, alluvium-covered Paloma district. One portion of the substructure, 9 ft 3 in. high, supports the 21-ton load of four 350 hp Superior gas engines, which power the rotary. Another portion of the substructure, 13 ft 3 in. high, supports the National 125 drawworks that weighs more than 38 tons.

The engine and drawworks substructure is separate from the derrick floor substructure so that vibrations from the heavy machinery will not be transmitted to the derrick and derrick floor. Derrick floor substructure is 15 ft high. Legs of the derrick are extended, so that the substructure independent of the derrick can be moved in or out. A special safety feature of the substructure is the ease of access to the cellar, blowout preventer and to the master gate controls.

Cantilever type supports eliminate the hazardous cross-bracing of a conventional substructure. There is enough clearance to drive a two-ton truck under the supporting beams. The substructure has casing or drill pipe support capacity of 450,000 lb and a rotary table support of 300,000 lb. Over-all length of the pipe

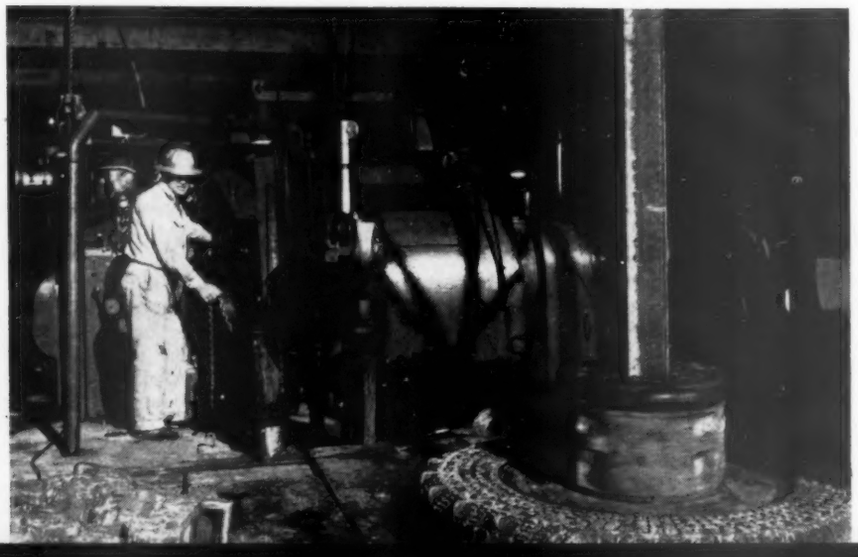
EXCLUSIVE



Ground level layout at the Paloma deep test.

Seated, Robert M. "Bob" Miller, division superintendent; C. W. Stephens, division petroleum engineer; R. W. Shoemaker, district geologist; *standing,* A. F. "Tony" Tokash, district production superintendent; Ben Hollandsworth, drilling superintendent.

Driller V. E. "Bill" Gillette keeps an experienced eye on the spinning rotary table from his vantage point beside the brake.



rack is 40 ft; width is 16 ft. It is made up of four prefabricated steel units, 3 ft 9 in. high, 8 ft wide and 20 ft long. The rack will support a casing load of 400,000 lb.

There are five safety platforms between the floor of the rig and the crown block, and run-a-round provides the safety platform on the outside of the derrick at the level of the 120 ft high "fourble" board.

A gin pole atop the derrick is used principally for placing the 8560-lb crown block during rig-up work. Capacity of the five-ton traveling block is 360 tons. The block has five 88-in. manganese steel sheaves. The hook weighs almost a ton and has a carrying capacity of 300 tons.

Assembled from prefabricated angle steel, the derrick weighs 67,037 lb. Fully rigged, the derrick, engines, drawworks, crown block, traveling block, and hook can readily hoist and control 300 tons.

The engine group and drawworks are set on a separate steel substructure four feet below derrick floor level. Guards over each coupling form a non-skid step. Ample space is provided between engines for easy access and safe working conditions. Two C-350 National mud pumps are used for circulating and another C-250 National mud pump is used for mixing. They are powered by two 350-hp Superior gas engines identical to those in the four-engine group that powers the drawworks. Each of the gas engines has a radiator that is 7 ft 7 in. high and has a cooling system capacity of 70 gal. Lubricating system for each of the engines has a capacity of 30 gal. Ohio's outfit features an independent rotary drive, driven by two G. M. C. twin diesels. Motors are connected to the National rotary table with an Oilwell torque converter.

Blowout equipment includes two Shaffer blowout heads and one Hyrdril head. One of the Shaffers is used on the bottom to afford a complete shut-off. The second, a ram-type head, shuts off around the drill pipe. The Hyrdril is used on top and is capable of a shut-off either on the drill-pipe, collars, kelly, or without anything in the hole.

With the exception of the rotary drive and the size of the drill pipe, equipment being used at Paloma is essentially the same as was used for the Michigan drilling job five years ago. Minor changes have been made in the equipment to conform to California safety regulations. For example, one d-c generator driven by the drawworks had to be replaced by an electrical generator located away from the well.

To date protection pipe cemented in the deep test includes 13⅜-in. casing cemented at 1431 ft with 1000 sacks, and 9⅝-in. casing cemented at 10,947 ft with 1200 sacks. Additional pipe on hand includes enough 5½-in. casing to complete the well at 22,500 ft, if findings should warrant completion from that record-breaking depth. Paloma sand, the field's regular producing horizon in the Stevens zone, was topped at 10,038 ft and shortly thereafter was cased-off.

As pipe was set at 10,947 ft, 5548 ft of 8¼-in. hole has been drilled to a depth

of 16,495 ft. Of this footage, 92 ft were drilled with 11 conventional rock bits for an average drilling rate of 1.2 ft per hour; 2817 ft were drilled with 13 diamond bits for an average drilling rate of 1.2 ft per hour; and 2639 ft were cored with four diamond core-heads for an average coring rate of 1.2 ft per hour. Footage obtained from any one diamond bit has varied from 81 ft in 93 hours for one drilling bit to 1147 ft in 86 hours for one coring bit. While rates of coring and drilling have been about the same, indications are that the coring bits give greater total footages per bit than the drilling bits. The diamond bits have amazing durability, and in the case of the drilling bits have been left on bottom for as long as seven days.

From 13,500 ft the drilling has consisted chiefly of coring. Ninety-five per cent of the total interval has been cored, the practice being to take 54-ft cores. There is also a rate of penetration indicator to add to the information regarding formations being penetrated.

Mud in the hole is an oil-base type mud. The weight is carried at 115 lb per cubic foot. Flow-line temperatures of the mud increased steadily from around 125 F at a depth of 11,000 ft to around 170 F at 15,500 ft and has remained fairly constant since that time.

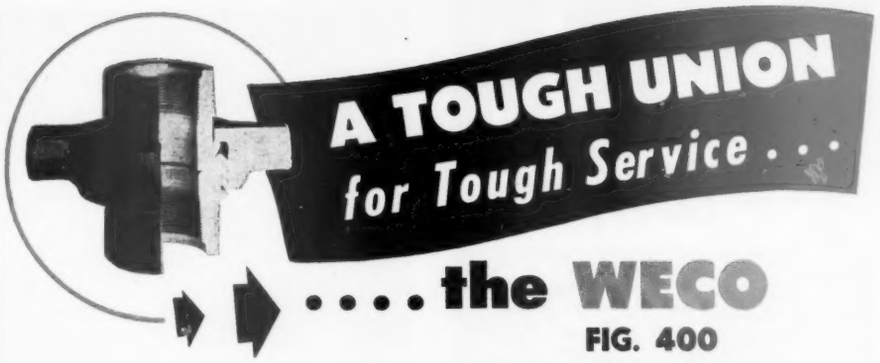
The 16,000 ft plus of 4½-in., 17.35 lb vanadium steel, integral-joint drill pipe imposes a considerable load on the ten 1¼-in. wire-center drilling lines. As a precaution, therefore, a definite program of moving and cutting the line has been followed. Between 15,00-16,000 ft, this moving and cutting program dictated that the line be moved a few feet, from 3 to 5 ft, after every round trip and that the line be cut 100 ft after every fourth round trip. Between 16.000-20,-000 ft, the program features the same moving procedure but dictates that the line be cut 100 ft after every third round trip.

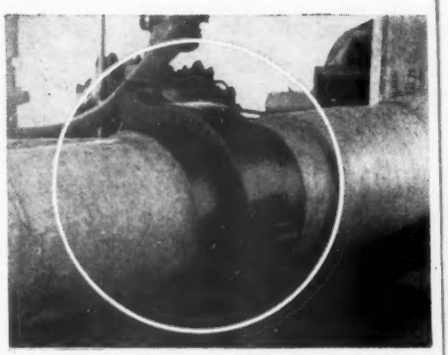
Only one serious fishing job occurred up to early December. It occurred at 16,495 ft when a core barrel was stuck on the bottom of the hole. After efforts to jar the fish loose had failed the hole was sidetracked 75 ft off bottom.

Some of the men who are playing a key role in the Paloma deep test include Robert M. "Bob" Miller, division superintendent and an Ohio oil man for more than 45 years; C. W. Stephens, division petroleum engineer; Don Everitts, petroleum engineer who has "sat on" the well; R. W. Shoemaker, district geologist; and Ben Hollandsworth, drilling superintendent. With the exception of Stephens, whose headquarters are in Los Angeles, all the Ohio men are located in Bakersfield.

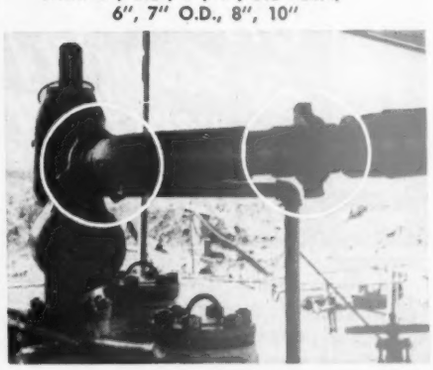
One record that has fallen to the deep test is that of the deepest penetration to date in the Paloma field. Previously the deepest test in the field was Superior Oil Company's Anderson No. 56-35, a 14.486-ft hole two miles northeast of the Ohio location. Superior's well was plugged back for completion in the Stevens zone.

Records that the Ohio deep test may challenge in the coming months are the deep drilling and producing records





The Weco Fig. 400 is ideal for pump suction connections.



Weco Fig. 400 unions save time in connecting up pump discharge lines.

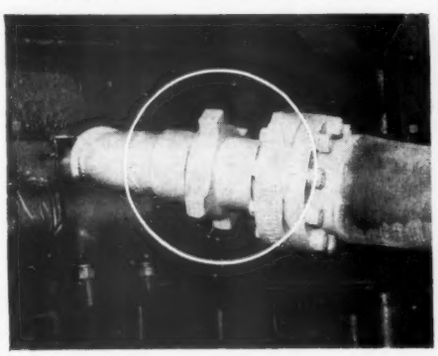
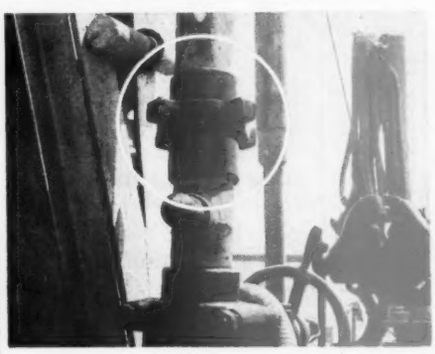


Fig. 400 Union on mud line.



4" Weco Fig. 400 Union on stand pipe.

● Unions in service on drilling rig lines get a lot of rough treatment. These mud, steam, water, oil, gas and other lines are made up and broken out frequently . . . carry fluids at high pressure with lots of vibration. The WECO Fig. 400 Union withstands more abuse in these tough services than any other union. Thicker sub end walls resist distortion . . . provide greater strength with less weight. The famous Weco ball and cone seat assures a perfect seal, every time.

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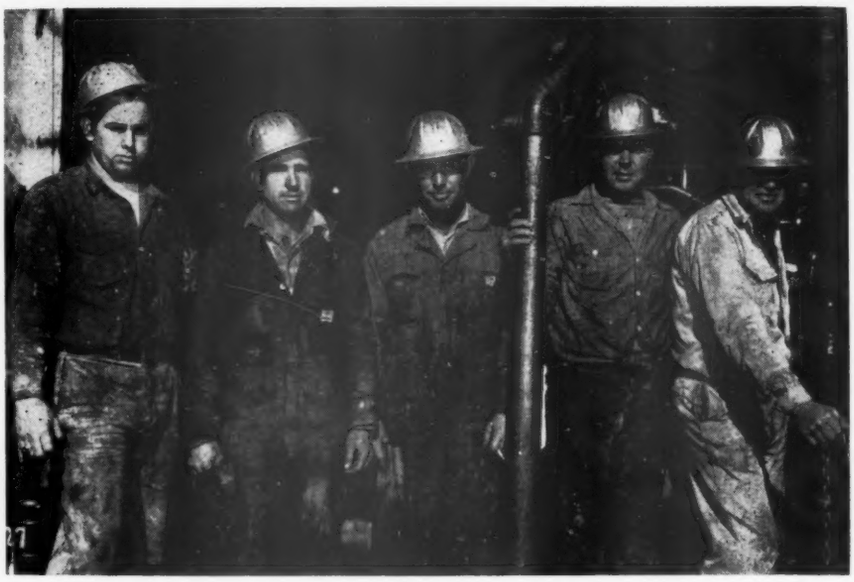

Members of one of the crews assigned to Ohio's deep test include: E. E. McCutcheon, rotary helper; J. J. Helton, derrickman; M. S. Sexton, rotary helper; Howard Weimer, rotary helper; and Bill Gillette, driller. All are from Bakersfield.

for California, and possibly the world's record for deep drilling and producing.

Two of those records are held by Superior Oil Company. Superior's Limoneira No. 1 in the North Montalvo area of Ventura County, California, went to 18,734 ft before abandonment in 1949 as the deepest well ever drilled in California. Superior's Pacific Creek Unit One in Sublette County, Wyoming, set a world's record for deep drilling three years ago at 20,521 ft. Superior drilled this project with a National 160, the only rotary larger than the National 125 being used at Paloma.

Pure Oil Company is believed to hold the world's record for deep production with a well that was completed this year in West Poison Spider field of Natrona county, Wyoming, from 16,102-607 ft. Pure's well which is now pumping, produced from the Morrison formation at 16,102 ft.

If Ohio is unable to complete for a new deep discovery, there is some doubt as to whether or not the well will be completed in the Paloma sand. Completion of the deep test, which is located between two producing wells, would disturb forty-acre spacing of the unitized Paloma field, which is unitized on the Paloma producing horizon in the Stevens zone.

Ohio Oil Company has the principal interest in the Paloma unit, 42 per cent, although Western Gulf Oil Company is the operator. Others in the unit include The Texas Company, Union Oil Company of California, Sunray Oil Corporation, Chanslor-Canfield Midway Oil Company, and General Petroleum Corporation.

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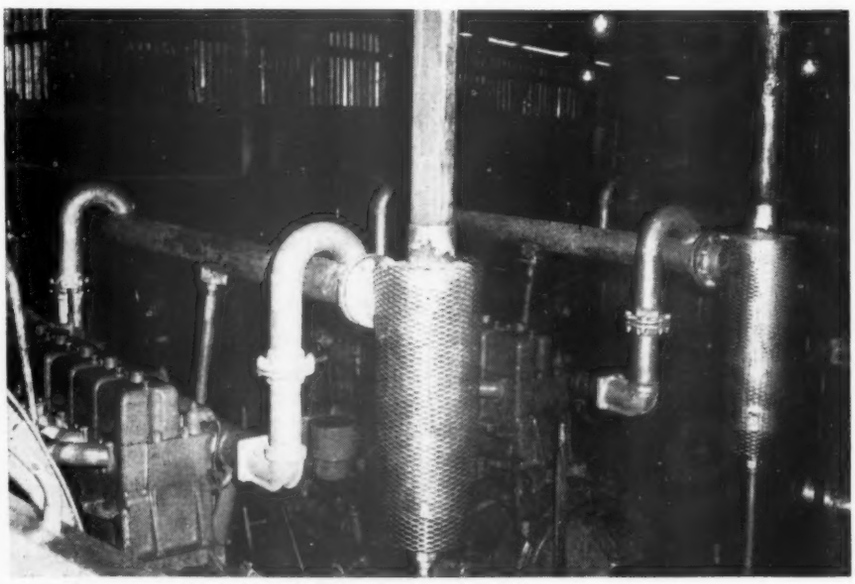


Four 350-hp gas engines power the rotary that may push Ohio's Paloma deep test to new depth records.

The Role of Mud in Deep Drilling

The frequency of fishing jobs and the difficulties involved have been largely reduced by mud engineers

VERNON B. ZACHER and BRUCE R. ZACHER

EXACTLY what is the role of rotary mud in deep drilling today? In order to best evaluate this we should treat the subject in two steps. First, the growth or development of mud technology since 1925. Second, the fast growth of mud work, which will give a reasonable picture of the future. (The near future will probably see some 20,000-ft holes being drilled).

Bringing Old Mud Practices Up to Date

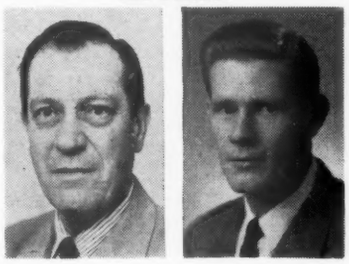
To attempt to bring 1925 to the present, statistically, would be a big job. That is, if one could possibly get the statistics. Naturally, these data are rather meager earlier than 1935 in most companies. Another difficulty is the apparent inconsistency of early data, due to a great many variables. The best method probably is to consider present conditions and make physical rather than monetary comparisons. The only exception to this would be that some average cost figures can be given on the mud itself. Also, we must bring out other items on the drilling operation besides the actual mud role in that this mud performance has caused vast improvements in the drilling operation. Being so connected with mud control, these improved drilling operations will be credited to mud thus to justify the admitted high mud costs. These improved drilling operations generally consist of the following:

1. Big reduction in tons of casing per foot of hole required to protect deep wells, as we can carry three or more times as much open hole as formerly. Naturally, the exceptions are when lost circulation, shale, etc., are troublesome. Money saved here is tremendous as statistics show that, allowing for a 40-cent dollar now (in comparison to 1925), the total tonnage of casing going into 10,000 to 12,000-ft holes is very little greater than the 5000-ft shallow holes of 1925 to 1930. Naturally smaller holes have helped reduce costs, but these, too, have been made possible by mud.

2. Drilling speed and faster round trips each day increase footage made about four times. Assume that bit design and other modern equipment* contribute as much as 50 per cent to this and we still have a doubled drilling speed credited to mud. At a tool rental of $60 per hour this amounts to a saving of 50 per cent outlay in money plus the advantage of time saved. Thus in two days the saving will be 50 per cent of $2 \times 24 \times \$60$, or $1440. It is hard to imagine how $720 per day can be made any easier. This amount will pay for a crew and pusher for approximately one day.

3. The marked reduction in twist-offs, stuck pipe, caving shale, and lost circulation due to mud control is admitted by anyone. The prevention and handling of troubles of this nature is so much improved that some mud men go through a long training period without ever encountering such troubles. The money saved here is enormous. As all will agree, a fishing job will cost ordinarily from $3000 to $10,000. Some jobs will be on the order of $30,000 to $40,000 in cost. These latter jobs are becoming less and less frequent today.

The Author



V. B. Zacher B. R. Zacher

Vernon B. Zacher has been test and mud engineer for Tide Water Associated Oil Company since 1930. He was graduated from Montana State College and the University of Montana, and holds a BS and ME degrees in mechanical engineering. He was sales engineer for testing and designing for Standard Oil Company from 1923 to 1925, and employed by Hall Scott Motor Car Company as design engineer from 1925 to 1926. He joined Tide Water in 1926.

Bruce R. Zacher, son of author mentioned above, is a drilling fluids engineer for Macco Corporation. Also a graduate of Montana State College, he has a BS degree in mechanical engineering. Zacher joined Shell Oil as a roustabout, and served in the same capacity with Chanslor-Canfield, and Midway Oil Company. He served 3 years in the army.

"Price Tag" on Drilling Muds of Today

On the other side of the ledger it may be said that the price tag on mud is high. Yet, compared to the enormous improvements mud work causes, this cost is low.

Generally grand total mud operations have now come up to an annual outlay of 250 million dollars* per year in the United States. These mud costs started actively increasing from a low, steady outlay in about the year 1933, resulting in a growth in twenty years of 250 million dollars, or $12,500,000 per year. This growth of 5 per cent per year is a fairly heavy one, although not out of line, considering that this was the price for getting the deep wells drilled at all. This 5 per cent investment paid back dividends of almost inestimable value. Let's look at the national picture of actual mud cost based on footage and "per well" drilled in 1952 (considering all wells both shallow and deep). Statistics of the October "Drilling Contractor" state that there will be 200,000,000 feet drilled in 1953. Of this footage about 25 per cent will be 10,000 to 12,000 feet in depth, leaving 75 per cent of the footage from 2500 to 8500 feet. Cost based on footage would be 250,000,000 dollars divided by 200,000,000 or $1.25 per foot for wells of all depths. Included are shallow wells as they all profitably use good (and expensive) muds. Naturally the deeper drilling will show a greater cost per foot, than the previous shallow drilling, on any deep well.

To check today's mud costs, first let us consider that our deeper wells at 10,000 to 12,000 ft will have a total cost of about $250,000. Since the average mud cost on these wells is $12,500 (this

*Examples of this modern equipment are: (1) The jet bits which in suitable formation will dig 1000 to 1200 ft per day. (2) The new pumps which will stand many more strokes per minute giving equivalent operation to cylinders 2 in. longer. These pumps also handle 4000 psi in routine operation. Proper mud is naturally a "must" using this equipment.

*McGraw Hill's *Chemical Week.*

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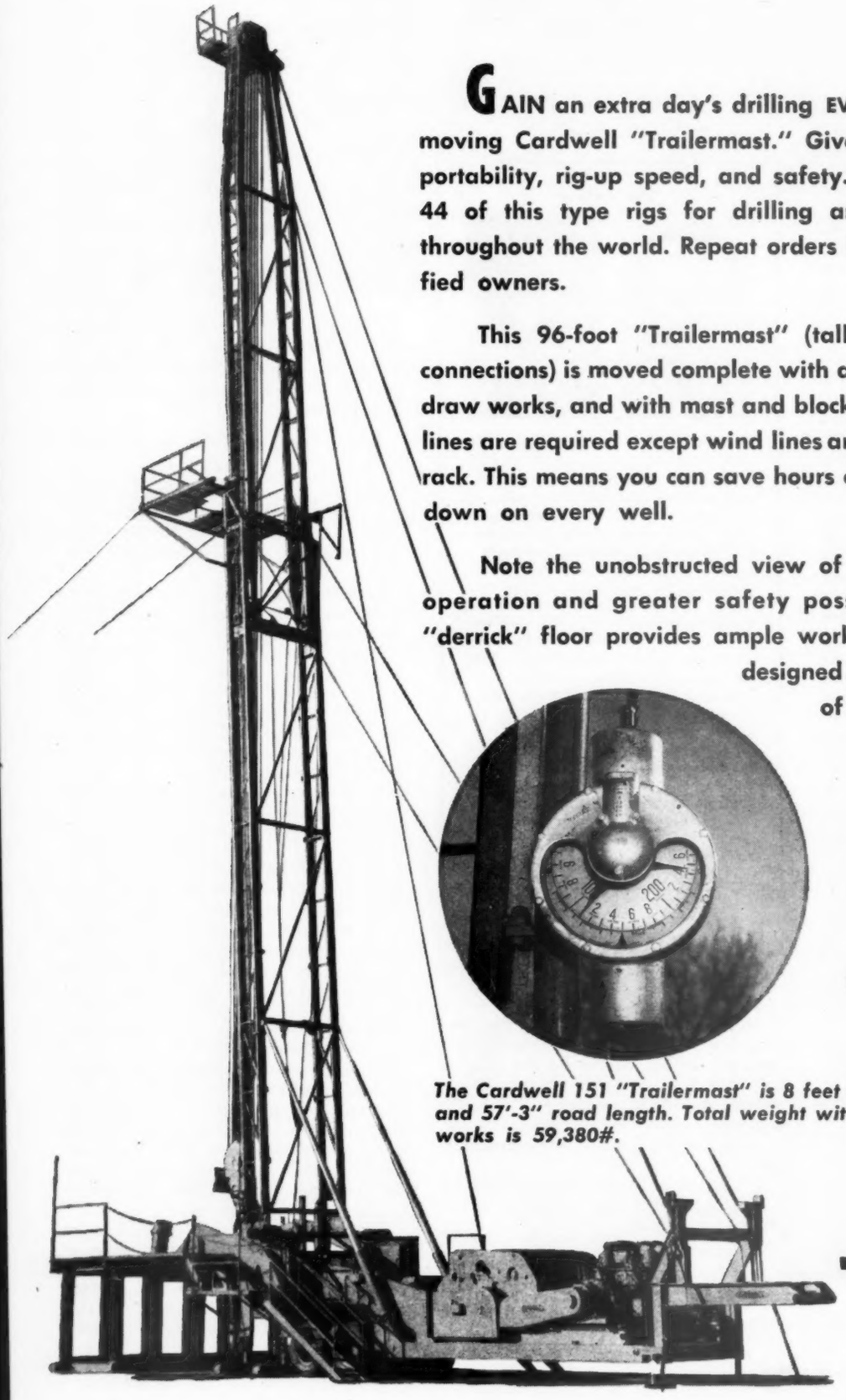

GAIN an extra day's drilling EVERY week with this fast-moving Cardwell "Trailermast." Gives you the maximum in portability, rig-up speed, and safety. Cardwell has delivered 44 of this type rigs for drilling and workover operations throughout the world. Repeat orders have come in from satisfied owners.

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Note the unobstructed view of the driller makes faster operation and greater safety possible. The big 16' x 16' "derrick" floor provides ample working space. The specially designed trailer eliminates the use of ramps and the substructure permits blowout preventers up to 10 feet high. The "Trailermast" can be used for workover or drilling.

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The Cardwell 151 "Trailermast" is 8 feet wide, has 12'-6" road height, and 57'-3" road length. Total weight with double drum Model L draw works is 59,380#.

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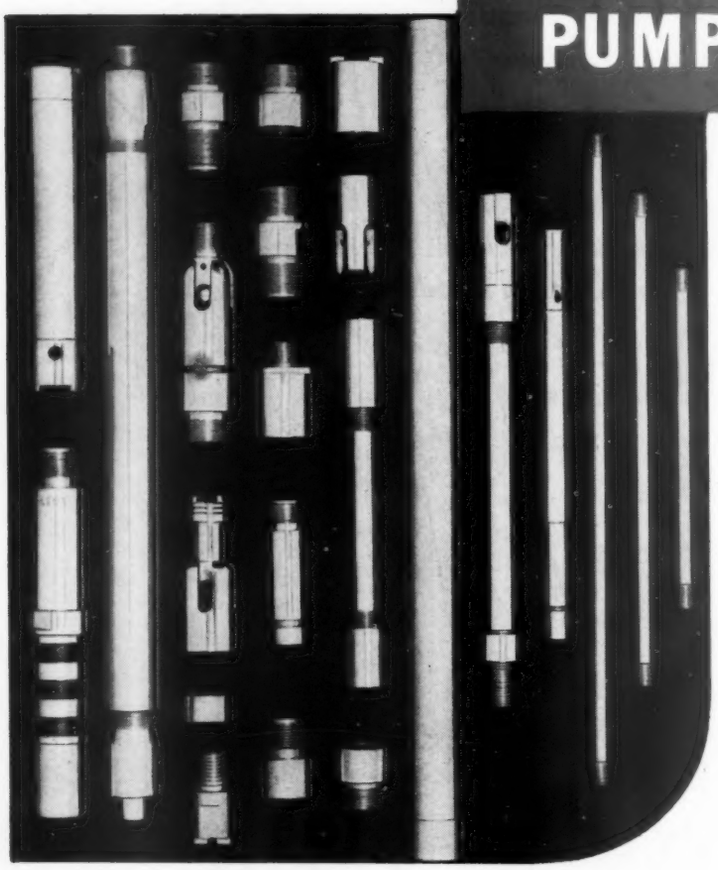

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figure is an average from a number of actual typical wells) cost of mud percentagewise is $12,500/250,000 or 5.

This 5 per cent is obviously a small price to pay for the advantages enumerated above. Of course, the exact advantage would depend on the well itself. Both shallow and deep holes vary in drilling difficulties depending upon locality and formation. On a number of deep wells detailed mud costs would be divided into several categories, together with average cost breakdown as follows:

	Average % of Total Cost of Mud
1. Weight materials and/or lost circulation materials	50
2. Rotary clays or muds	15
3. Chemicals, emulsifiers, etc.	20
4. Technical services (laboratory and field)	15

Actual Muds of the Future

What would be a reasonable estimate of the mud of the future, 1960 to 1970 drilling? We should first consider the wide gulf between the clay or "gumbo" water muds of 1925 compared with those of 25 years later. The muds of today have reached a high state of development as to characteristics, such as fluid-loss, viscosity, gel character, etc. These muds can be chemically treated to cure impurities and also can be easily weighted to give sufficient hydrostatic pressure on formation. Yet, assuming this improvement (and let's face it) these muds will fail in several respects in future holes. These deeper holes will demand muds that will keep holes absolutely to gage. Also, rather than fight fluid-loss, the muds will have to test "zero" or nearly so. Here, any high fluid loss could not be tolerated. Newer concepts of these muds will, as in all development work, make these things possible.

What is meant by "new concepts" is that comprehensive research in the near future will turn to more or less revolutionary ideas in drilling and completion fluids. At present, in the development stage are laboratories now working on muds better suited for these deeper holes. This work is, and will be, stimulated by the endless variety of chemicals now developed (possibly for other purposes). Suitable and experienced mud technicians who did not formerly exist, are available now. As these technicians include a goodly percentage of inventors, these people will produce the muds required. Right now very promising work is being done on several of these muds.

The above is merely based on usual development in design of an article. The first automobile had a buggy whip holder and other horse drawn carriage equipment. New inventions, piece-meal mostly, together with the Ketterings and the Olds, produced a car never imagined by the early designers.

Thus, as mud has played the big, starring role in past drilling, it will probably play a very much more important role in the more difficult future drilling. * * *

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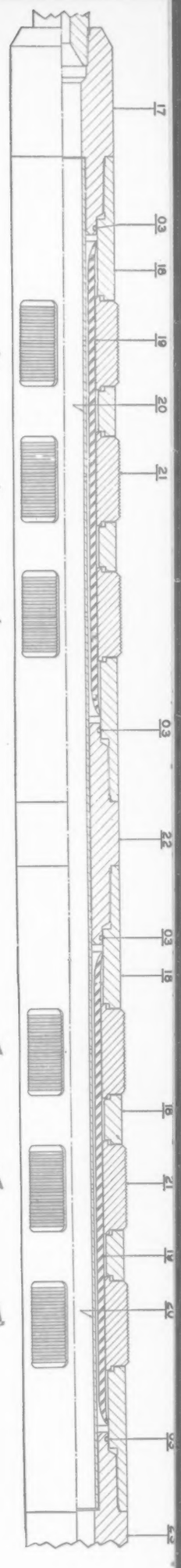

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21 — Slips
22 — Body Connector
23 — Bottom Connector

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CROOKED HOLES*

Need for definition of hole crookedness in which degree of crookedness corresponds to degree of possible drilling and producing troubles

ARTHUR LUBINSKI†

WITH a view toward determining the relations between hole crookedness and rod and tubing wear, some close-spaced directional surveys were made in the casing in a few wells where rod and tubing wear was believed to be due to crooked holes. These surveys were made by the gyroscopic-compass multi-shot method. The distance between successive shots was about 20 ft.

Four wells were selected in widely scattered areas, namely, in the Gulf Coast, in North Louisiana, and in the Rocky Mountains. The maximum values of the angle of inclination in these four wells were 12, 7, 6, and 2¼ deg. Because of the relatively high value of this angle in the first three wells, these holes had been referred to as "crooked."

Actually, the angle of inclination itself is not a measure of crookedness.

*Presented at Twelfth Annual Meeting AAODC. Oklahoma City. September 1952.

†Stanolind Oil and Gas Company, Tulsa, Oklahoma.

The Author

Arthur Lubinski is associated with Stanolind Oil and Gas Company, and prior to that with Barnsdall Research Corporation. He was graduated from the University of Brussels, Belgium, where he studied electrical and electrochemical engineering. Before World War II he was research and development engineer in Belgium and during the war served the French Forces of the Interior (French underground). From 1945-46 he was a French public official in a department for emergency rebuilding of a war-destroyed area, arriving in the USA early in 1947. He is a member of API and AIME. In the last few years he presented a few papers concerning buckling of pipe and straight hole problems.

It has already been explained[1] that a hole which is inclined, but straight, i.e., without any dog legs, would present very few problems. It has also been shown that the sharpness of a dog leg may be defined as the "rate of change of the overall angle in space in degrees per 100 ft."[2,3]

With the data from the directional surveys, the rate of change of the overall angles was calculated for the four above-mentioned wells, and the surprising result was that in no place in any of these wells did the rate of change of the overall angle approach the value of 5 deg per 100 ft, which is generally considered as safe in ordinary circumstances in directional drilling.[2] Consequently, all these holes, although thought of as "crooked," were actually "straight."

The wear of tubing was obviously not due to hole crookedness. Troubles due to crookedness should be expected to be at a considerable distance from bottom where tension is greater, whereas all the tubing leaks reported were close to the bottom, generally within 300 ft of the lowest end of the strings. Further mathematical analysis has indicated that such wear is due to buckling of the tubing string due to unbalanced pressure during the upstrokes of the pump. The explanation and suggested remedies are, however, outside of the interest of this discussion.

A conclusion that may be reached from the above-mentioned surveys is further confirmation of the point brought out by R. B. McCloy in a recent paper[4] and by W. W. Moore in the discussion of that paper, namely, that a clause that specifies only maximum deviation, as now used in drilling contracts and which increases drilling costs, is not logical. Although three of the above-mentioned holes were appreciably inclined, none of them were crooked. There is a definite need for a definition of hole crookedness in which the degree of crookedness would correspond to the degree of possible drilling and production troubles. The API Mid-Continent Study Committee on Bore Hole Drift is working on this problem, and needs the help of the industry to accumulate appropriate information toward solving it. This Committee urges that close-spaced directional surveys be run in any hole in which drilling or production troubles are suspected to be due to hole crookedness and that such surveys, together with the description of troubles, should be mailed to the Committee at the following address:

T. W. Keating, Chairman
Mid-Continent Study Committee
on Bore Hole Drift
Stanolind Oil and Gas Company
P. O. Box 591
Tulsa, Oklahoma.

Conclusions

(1) Some holes referred to as "crooked holes" actually should not be called crooked, because the degree of dog legging, i.e., the rate of change of the overall angle, is small.

(2) Production troubles, such as tubing leaks due to rod wear in pumping wells, are probably not due to hole crookedness if they occur close to the bottom of the string.

(3) Crooked hole troubles might be expected far from bottom, where the amount of tension is large.

(4) It is desirable to have close-spaced directional surveys made in holes in which drilling or production troubles are suspected to be due to hole crookedness, in order to clarify the relationships between trouble and crookedness so that the desirable specifications for drilling might be more correctly expressed.

(5) The API Mid-Continent Study Committee on Bore Hole Drift will investigate all the data and records with which it would be provided.

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1. "Straight-Hole Drilling in Crooked-Hole Country," by G. C. MacDonald and Arthur Lubinski, *Drilling and Production Practice*, 1951, API.
2. "Planning a Multiple Well Directional Drilling Program for Offshore Locations," by John G. Jackson and J. B. Murdoch, Jr., American Institute of Mining and Metallurgical Engineers, Technical Publication No. 2325, Class G, *Petroleum Technology*, March 1948.
3. "Report of API Committee Discussion on Bore Hole Drift," by G. C. MacDonald, *The Drilling Contractor*, Vol. VIII, No. 2, February 15, 1952.
4. "The Need for Definition of a Crooked Hole," by R. B. McCloy, presented at Spring Meeting of the Southwestern District, API Division of Production, March 5-6-7, 1952, and at the Spring Meeting of the Mid-Continent District, API Division of Production, March 19-20-21, 1952.

★ ★ ★

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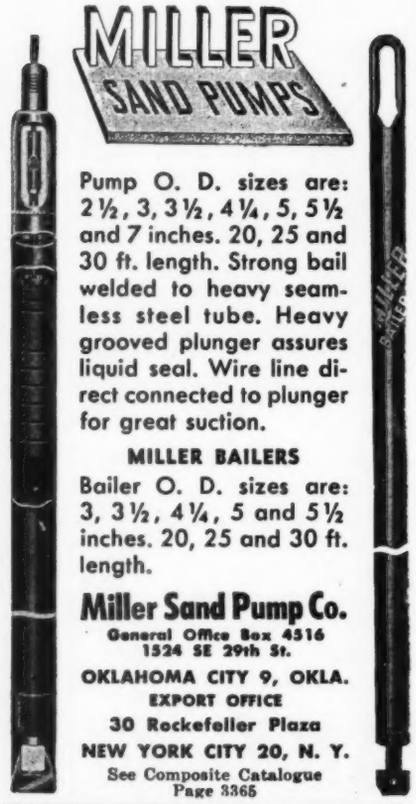

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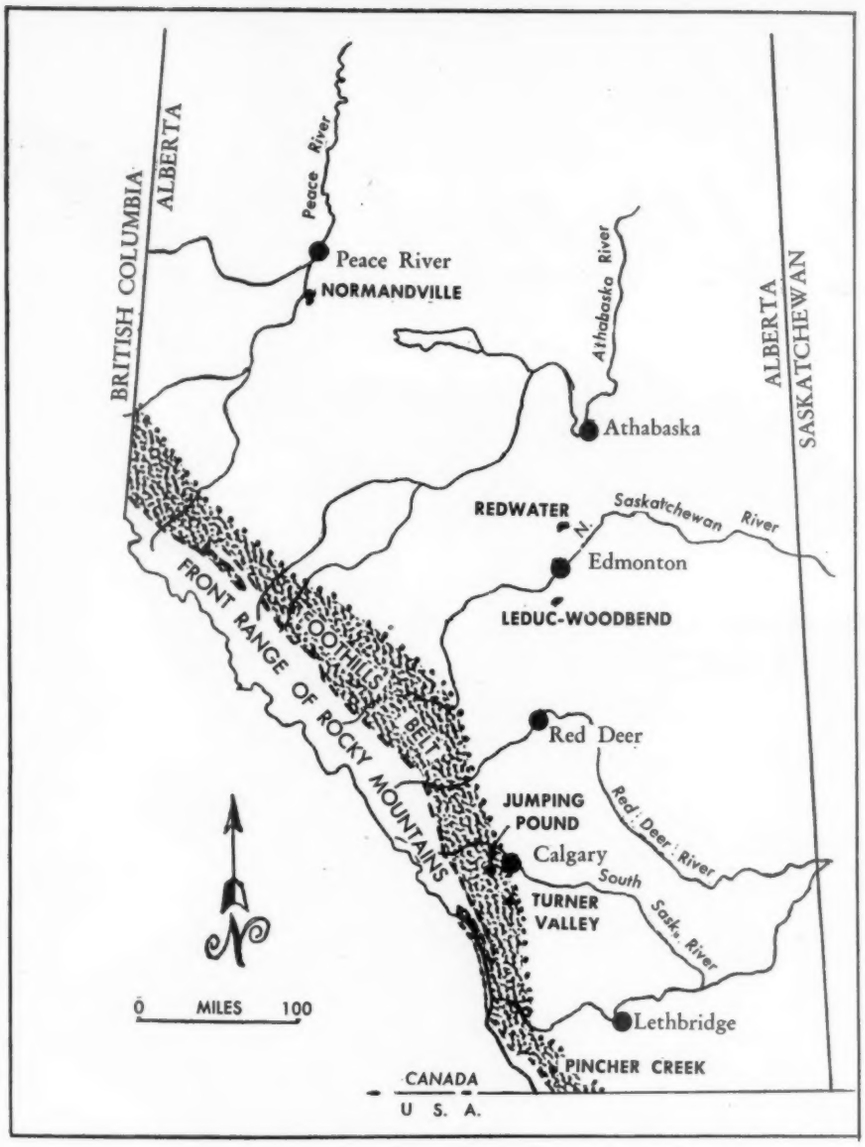


FIG. 1. Areal extent of Western Canadian foothills, the crooked hole country.

Drilling 75 Degree Dips in Canada

Deep operations are carried out in difficult and crooked-hole Foothills country where the rate of penetration is slow by design

JACK MENNEER*

Under the best of circumstances, it requires a continuous vigilance to insure that a well is drilled straight. How much more this is the case when formations having dips ranging between 25 and 75 deg have to be penetrated.

Unless the drilling is scientifically planned, ultimate failure will result. Know-how is an essential quality when operating in the crooked hole country of the Canadian Rockies.

Shell Oil Company of Canada is tackling the crooked hole problem and has experienced considerable success. But, nevertheless, all the problems are not solved as yet. If they were, no doubt a more intensive drilling campaign would be undertaken by many operators in the Foothills region.

An appreciation of some of the difficulties when drilling in Canadian crooked hole country is presented, and how the problems are being overcome is discussed.

*Editor Drilling and Producing.

EXCLUSIVE

HE fact that a routine well drilled to 10,000 ft requires an expenditure in excess of $400,000 demonstrates that operating conditions are far from normal. This is the case when drilling in the Foothills of the Canadian Rockies where steep-dipping, overlying formations have to be penetrated. Some of these structures have dips as high as 75 deg and not less than 25 deg. To date it has not been possible to keep the deviations below 3 deg, but the maximum has been 6 deg.

Although it is presently impossible to drill a vertical hole in the area, the problem is not one of attempting to drill such, but it is essentially one of trying to restrict the deviation to within 3 deg. This is a formidable task and requires all the skill and engineering that can be applied and a deficiency in appropriate know-how will surely lead to failure.

Crooked Hole Area

The crooked hole country of Western Canada is in the Foothills belt of the Rocky Mountain range and it is some 600 miles long and about 30 miles wide. (See Fig. 1). Three major fields have been discovered within the area; Turner Valley which is an oil and gas producer, and the two gas fields, Jumping Pound and Pincher Creek.

The region is one of highly complex structures and faults. Over-thrusts are common and in some wells the same formation has been penetrated many times. Due to the deviated holes that result—or more aptly expressed, due to the serious deviations that can occur—this type of drilling is known colloquially as "foothill" and has the general name of crooked hole. The drilling is costly and some have been forced to abandon completely their operations in this difficult area.

In order to evaluate crooked hole

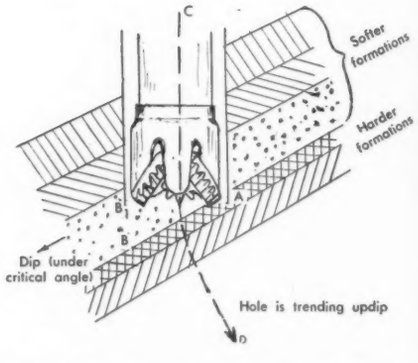


FIG. 2. A hyopthetical up-dip directional trend in crooked hole drilling.

drilling tendencies two considerations are necessary.

1. Tectonic, or Structural
   (a) Dip
   (b) Strike
2. Mechanical
   (a) Bit weight
   (b) Rotary speed
   (c) Hydraulic volume

A summary discussion follows and it is pointed out that in (1) above, alternative titles are given as the relationship between the regional tectonics of the Canadian Rockies and the areal structural features is one of close affiliation.

1. Tectonic, or Structural Influence.
   (a) and (b) Dip and Strike.

When drilling a formation that has a dip less than a certain critical angle, the tendency is for the bit to deviate up-dip. Conversely, the bit will follow the general direction of the dip when the dip is in excess of the critical angle. The provoking question is, however, "What is the critical angle?" Every effort is being made to assess this important factor and some progress has been made in the determination. But the overall picture is still fogged by many conflicting and unexplicable circumstances. For example, the geology and tectonics are such complexities that the true structural patterns have not been completely unraveled at the present time.

One hypothetical consideration of the up-dip trend for case 1 may be explained as follows: (See Fig. 2). When the bit pierces the harder formation at point A, the line of least resistance is B_1B (the softer formation), and in consequence, the left hand side of the bit makes more progress than the right. The resultant direction is along the line CD, which is trending up-dip. In this case, the dip of the beds is assumed to be less than the critical angle. The increase in the angle of dip that would cause the bit to trend directionally down-dip is the important but difficult problem. It is reiterated that wide variations occur and no definite rules can be adhered to as yet. (It should

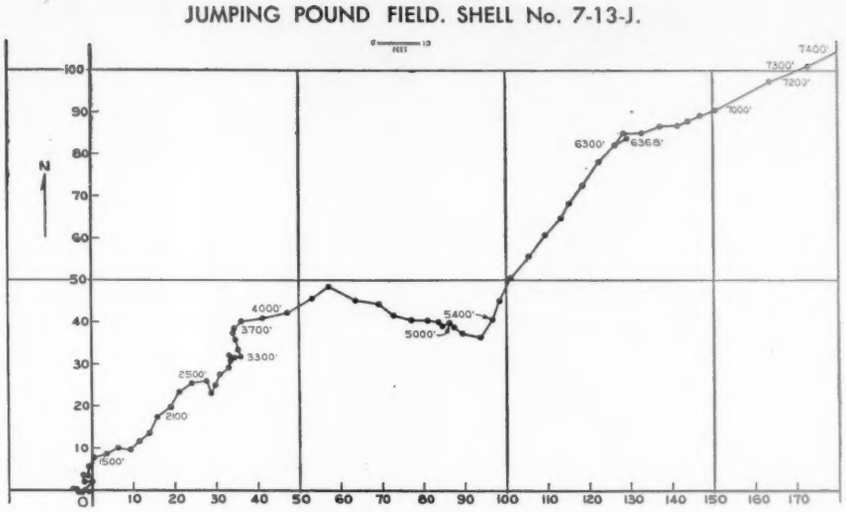


FIG. 3. Horizontal plot of photo clinometer survey.

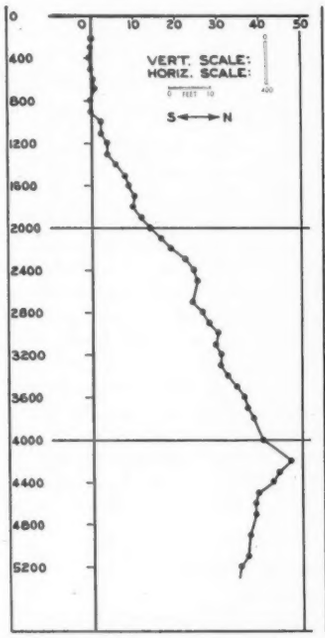


FIG. 4. N-S vertical projection of photo clinometer survey.

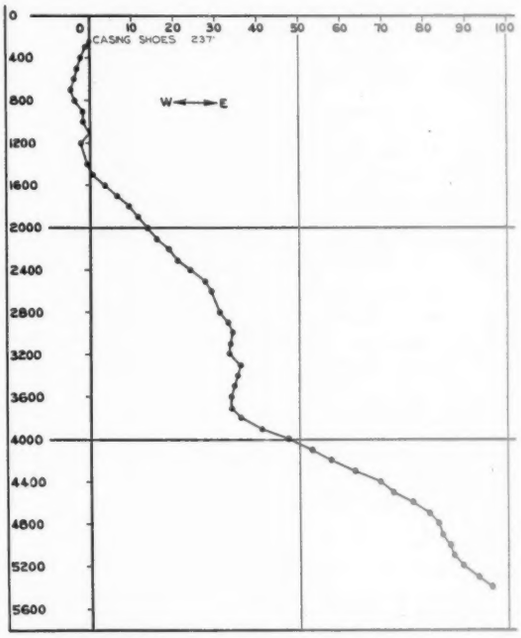
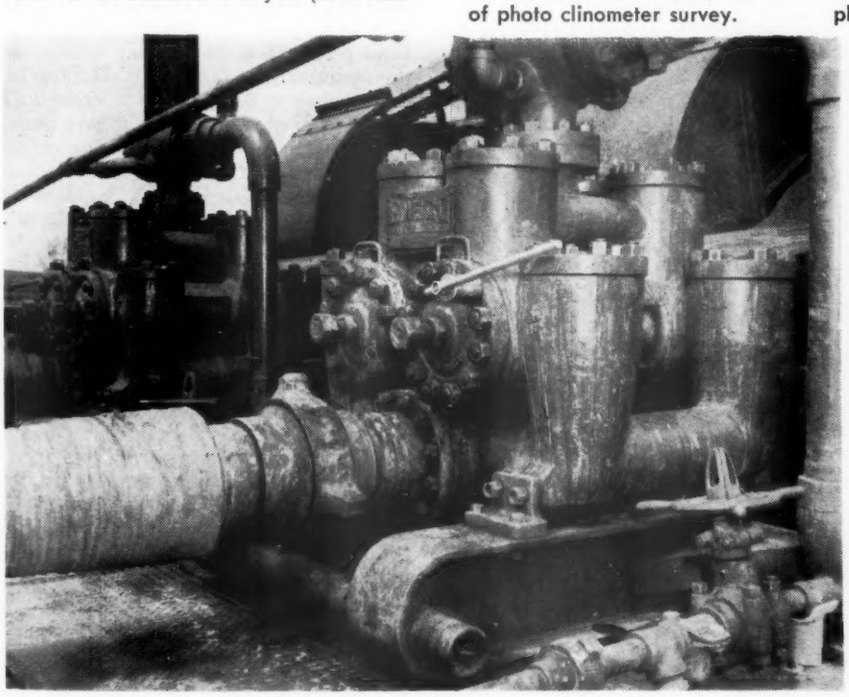


FIG. 5. E-W vertical projection of photo clinometer survey.



Control of circulating volumes is necessary in order to prevent heaving shale or washouts in the Cretaceous formations. An oil emulsion mud of 16 per cent is carried.

be mentioned that hard formations in the true sense of the word are not normally encountered in most of the section and roller type bits are usually employed).

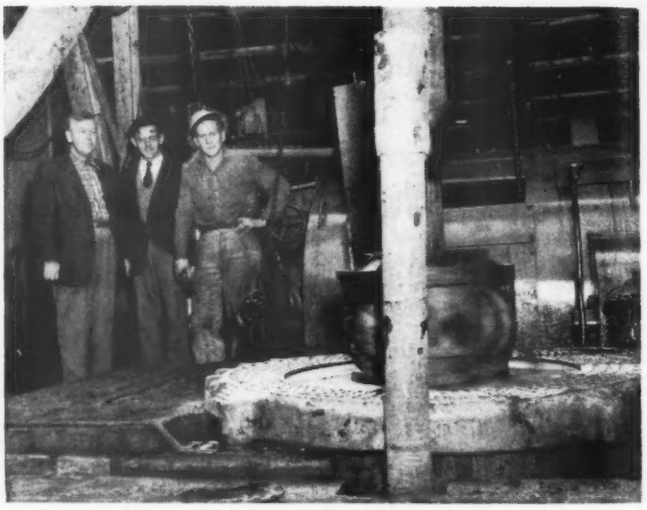
A directional tendency, without being too specific, for the Shell Jumping Pound wells is NE or SW in a field that has a NNW-SSE strike. The field is situated in the foothill belt just west of Calgary, Alberta, (See Fig. 1) and wells are drilled to about 10,000 ft. At 7400 ft in the 7-13-J well, the horizontal deflection was 101 ft to the north, and 173 ft to the east. (See Figs. 3, 4 and 5.)

Mechanical

(a) Bit Weight.

The weight to be placed on the bit is mainly governed by the particular dis-

The study of ditch cuttings is an important one when drilling in crooked hole areas. Bill Kellock, Shell exploitation engineer, analyses foothill formations.



Shell Unit No. 8, Jumping Pound. Drilling in crooked hole country at 6000 ft. The dips are as high as 75 deg. Left to right, C. R. Rhodes, drilling superintendent, Shell, Calgary; P. Gilpkie, exploitation engineer, and M. C. Kruse, driller for Loffland Bros.

position of the formation penetrated at any time. For the Jumping Pound area, generally speaking the most satisfactory results to date have been obtained when maintaining a weight of 2000 lb on the bit. The rate of penetration is of course slow, about 30 ft per day, but advancement must be sacrificed so that a relatively straight hole can be drilled.

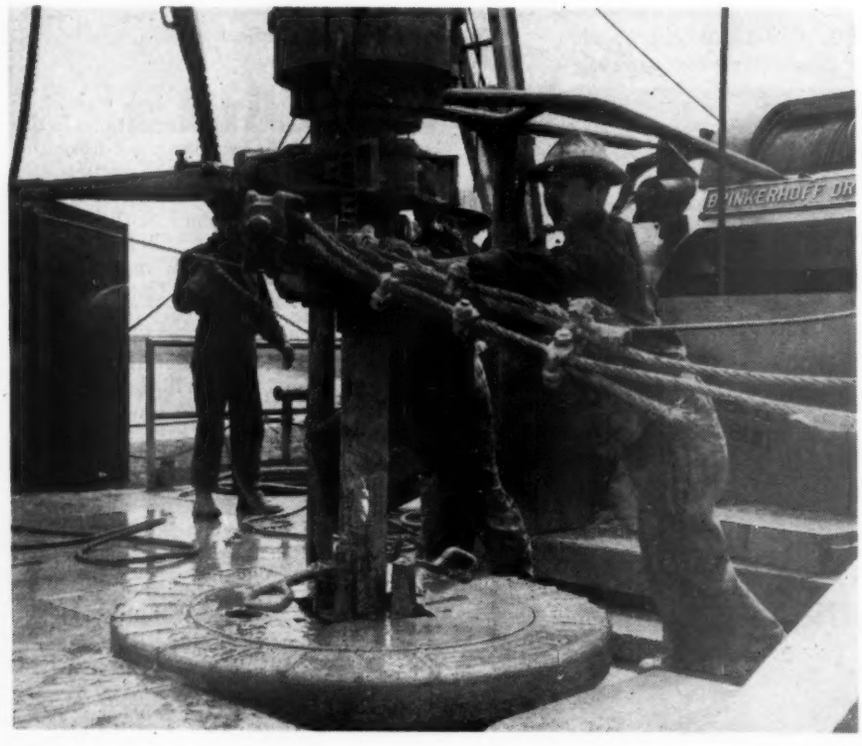
(b) Rotary Speed.

In general, it has been found in the Western Canadian crooked hole area that because more cutting action is obtained when a fast rotational speed is employed, a straighter hole results. A rotary table speed of 200 rpm has proved to be the most suitable.

(c) Hydraulic volume.

Cleavage planes of the Foothill formations are usually parallel to the dip and afford the least line of resistance to a penetrating bit. Local experience has shown that generally when high fluid volumes, or in other words higher fluid pressures, are exerted on a formation with the cleavage plane characteristic, then the tendency is for the bit to proceed directionally down-dip. Another disturbing factor in connection with hydraulic volumes is the heaving shale tendency, or perhaps a washout, of the Cretaceous formations. Excessive circulating volumes may cause additional operational difficulties in the Foothills.

Shell Unit No. 9, Jumping Pound. Spudded on June 8, 1952. Photo taken on Friday, June 13, 1952, when at 580 ft well had a deviation of 2 deg. Drilling 8¼-in. hole to be reamed to 15-in. and deviation corrected.



Experimentation

Many devices and techniques, which are listed below, have been used in an attempt to drill straight holes in the precarious Foothills.

(1) Percussion drill
(2) Hydraulic tool
(3) Drill collar variations
(4) Stabilizing reamers
(5) Controlled drilling
(6) Diamond coring
(7) Drill collar stabilizers

Each device or technique has served a useful purpose in the advancement for a better understanding of crooked hole drilling peculiarities. The percussion drill and hydraulic tool were used for a brief period, but mechanical difficulties precluded any further use. Variations in the number of drill collars of from 2 to 9 have been tried and the standard practice is now to use three. Stabilizing reamers have met with considerable success and controlled drilling is conducted. Various weights on the bit and different rotational speeds have been applied. It is found that a 2000 lb weight on a bit, a rotational speed of 200 rpm, and an average rate of penetration of some 30 ft per day is the most satisfactory combination. To date an average rate in excess of 30 ft would cause deviation trouble. The application of diamond coring to prevent deviated holes has been used, but as with the present practice, a restrictive drilling policy was also necessary. Drill collar stabilizers were recently adopted and it is hoped that they will be effective.

Many problems remain to be solved concerning the crooked hole drilling belt and in the answers may be found a way to drill a less expensive well than is presently possible. * * *

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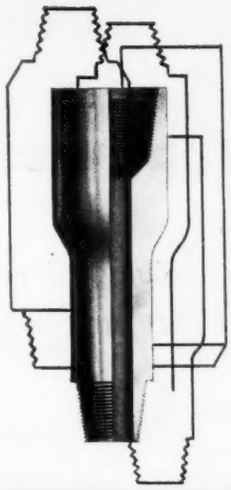

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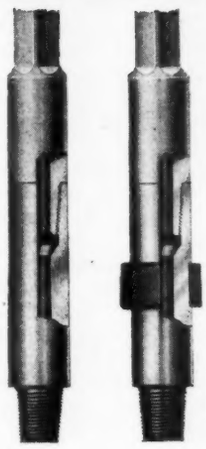

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Large Horsepower Pumps Save Rig Time†

Liner size, volume of mud circulated, pressure losses, and bit nozzle size are factors in successful drilling operation

EARLE C. HELLUMS*

HYDRAULIC horsepower requirements of a drilling rig have increased tremendously during the past five years. Deeper drilling and the economic necessity of faster drilling are responsible for these increased requirements. New methods and new techniques have made it possible to utilize larger pumps that are capable of delivering 700 hydraulic horsepower and effect economies by doing so.

Requirements for increased hydraulic horsepower on steam rigs can be accomplished by operating mud pumps in series, and by adding boilers if necessary. In the case of engine-driven rigs using power pumps the problem is not so easy. Until recently the available power pumps were not of sufficient size to deliver the desired hydraulic horsepower when operated singly. Experience has indicated that it has not been satisfactory to operate power pumps in series for any length of time. (It is understood that one company has recently been successful in operating power pumps in series.) In recognition of the need for a larger pump manufacturers now have available power pumps that will deliver 700 hydraulic horsepower. Pumps of this type have been used in the Gulf Coast, West Texas, Wyoming, California, and South America. It is regrettable that complete data are not available from a number of areas where these large power pumps have been used.

This paper presents data obtained from wells drilled in the Gulf Coast area showing results that have been accomplished with pumps capable of delivering 700 hydraulic horsepower.

Discussion

The required capacity of the mud pump for a drilling rig is determined by the maximum hydraulic horsepower requirement of the mud circulating system, which depends upon the volume to be circulated and the pressure required to circulate such volume. The volume circulated should be large enough to produce an annular return velocity that is adequate to remove efficiently cuttings from the hole. Some operators prefer to maintain annular velocities as high as 175 ft per minute, whereas others are of the opinion that a velocity of 125 ft per minute may be adequate. The pressure required is the result of four principal elements of the rig circulating system, which are as follows:

1. Friction losses through the inside of the drill pipe and drill collars.
2. Friction losses in the annulus between the well bore and the outside of the drill string.
3. Friction losses through the surface connections, including the mud lines, stand pipe, hose, swivel, kelly, etc.
4. Pressure drop across the bit nozzles.

The friction losses through the inside of the drill string increase rapidly as the volume circulated is increased. Due to this fact careful consideration should be given the volume to be circulated. If the volume is larger than required, the pressure required will be much larger than necessary, which will result in a waste of hydraulic horsepower. The following example will illustrate the effect of increased volume on the friction losses in the drill pipe and on the hydraulic horsepower required:

It requires 305 hydraulic horsepower to circulate 500 gal per minute through 12,000 ft of 4½-in. drill pipe because of the 1044 psi friction loss. 530 hydraulic horsepower are required to circulate 600 gal per minute through the same drill pipe, because of a friction loss of 1512 psi, which is an increase of 468 psi.

Friction losses through the annulus and through the surface connections are important, but they are relatively small compared to the drill pipe losses. The pressure drop across the bit nozzles will vary according to the size of the nozzles used, however, this pressure drop imparts energy to the bit fluid jet stream, which has a direct effect on the drilling rate. Under conditions of maximum effective bit weights and optimum rotary speeds, the drilling rate of a blade bit or rock bit is dependent upon the ability of the fluid jet stream to do work, i.e., disintegrate the cuttings, keep the bit clean, and scour the bottom of the hole. The ability of the fluid jet stream to do work depends upon the energy contained therein, which is the product of the volume circulated and the velocity of the jet stream. As has been pointed out in other papers, an increase in the energy of the fluid jet stream can best be obtained by increasing the velocity rather than the volume. This is done by using the smallest size bit nozzles that the available hydraulic horsepower will permit while circulating a sufficient volume to give the required annular velocity.

Drilling records on a number of wells in various areas where the rigs were equipped with 700 hp pumps were studied, but most of the data were not complete and an analysis could not be made. Complete data were available on the wells listed in Table 1, and a comparison is made showing the effect of pump horsepower.

The first comparison covers the interval drilled from 3500 ft to 8200 ft in three wells. There were 438 hydraulic horsepower used to drill well No. 1. The hydraulic horsepower was increased on

TABLE 1. Comparison of drilling data showing the effect of pump horsepower.

Location	Well number	Average hydraulic horsepower	Average circulating rate-GPM	Number and type bits*	Total feet drilled	Average feet per bit	Increase in footage per bit per cent	Average drilling rate—ft per hour	Increase in drilling rate per cent	Drilling time saved hours
				Interval — 3500 to 8200						
South Louisiana Terrebonne Parish.....	1	438	540	6 JD	4095	683	....	41.4	....	..
	2	550	540	3 JD 2 JR	4641	928	35.9	54.7	32.2	24
	3	691	620	4 JD	4620	1155	24.5	68.0	24.3	17
				Interval — 8000 to 10,500						
South Louisiana Terrebonne Parish.....	1	490	525	10 CR	2423	242	....	13.2	....	..
	2	485	505	7 JD 3 JR	2335	234	....	15.0	12.0	21
	3	525	528	1 JD 5 JR 1 CR	2178	311	32.9	16.0	6.7	9
	4	606	520	7 JD	2334	333	7.1	20.9	30.6	22

* JD—Jet drag; JR—Jet rock; CR—Conventional rock.

†Presented at twelfth annual meeting American Association of Oilwell Drilling Contractors, Oklahoma City, September 29, 1952, under the title "The Performance of Power Pumps in the 700 Hydraulic Horsepower Class."

*Vice president, Cron and Gracey Corporation, Houston, Texas.

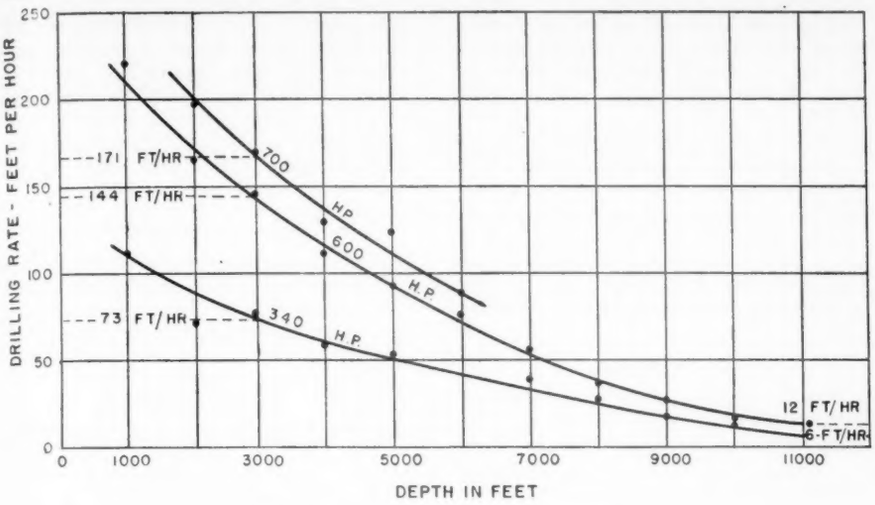

FIG. 1. Hydraulic horsepower study of wells drilled in South Louisiana.

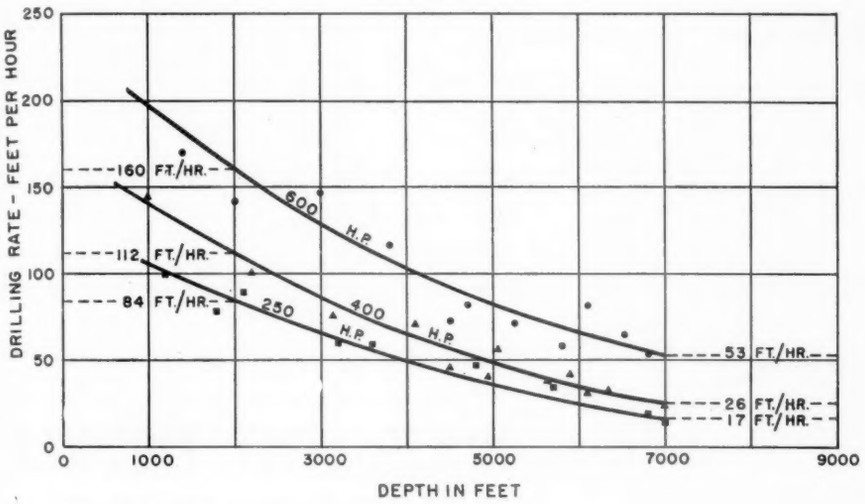

FIG. 2. Hydraulic horsepower study of wells drilled at Golden Meadow, Louisiana.

well No. 2 to 550, which resulted in an increase of 35.9 per cent in footage per bit and a 32.2 per cent increase in the drilling rate, thereby saving 24 drilling hours. The hydraulic horsepower was increased to 691 on well No. 3. As compared to well No. 2, the result was an increase of 24.5 per cent in footage per bit and an increase of 24.3 per cent in the drilling rate, which saved 17 hours' drilling time.

The second comparison covers the interval drilled from 8000 ft to 10,500 ft in four wells. There were 490 hydraulic horsepower used to drill well No. 1, where conventional rock bits were run. The hydraulic horsepower was approximately the same on well No. 2; but jet drag bits and jet rock bits were run, which resulted in an increase of 12 per cent in the drilling rate, thereby saving 21 drilling hours. On well No. 3, the hydraulic horsepower was increased to 525, which resulted in an increase of 32.9 per cent in footage per bit and an increase of 6.7 per cent in the drilling rate, thereby saving 9 hr drilling time, as compared to well No. 2. On well No. 4 the hydraulic horsepower was increased to 606, which resulted in a further increase of 7.1 per cent in footage per bit and an increase of 30.6 per cent in the drilling rate, compared to well No. 3, saving 22 drilling hours.

The comparative drilling data definitely indicate that each increase in the hydraulic horsepower results in a corresponding increase in the drilling rate.

A study of deep-well drilling in South Louisiana showing the effect of hydraulic horsepower on the drilling rate is presented in Fig. 1. The curves are based on data obtained from wells drilled by one operator in that area. Maximum effective bit weights were applied and optimum rotary speeds based on the driller's experience were used. Definite drilling rates for depths from 1000 to 11,000 ft are shown for 340 and 600 hydraulic horsepower. Drilling rates for depths from 2000 to 6000 ft are shown for 700 hydraulic horsepower. There were no data available for 700 hydraulic horsepower below 6000 ft. The study indicates that the drilling rate is approximately proportional to the hydraulic horsepower applied, each increase in hydraulic horsepower resulting

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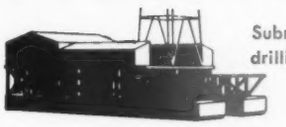
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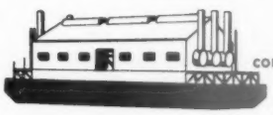
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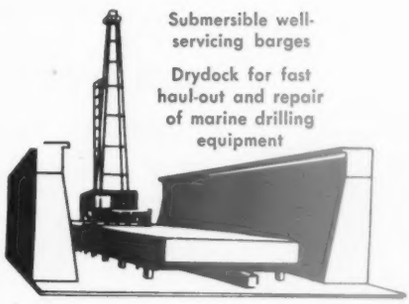
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in a corresponding increase in the drilling rate.

Fig. 2 was prepared from data obtained from wells drilled in the Golden Meadow field in South Louisiana. Definite drilling rates for depths from 1000 to 7000 ft are shown for 250, 400, and 600 hydraulic horsepower. This study also shows the benefit that can be derived from the use of a pump capable of large hydraulic horsepower output.

It is hoped that in the future operators will record complete drilling data so that studies can be made of the performance in all areas. All the companies using these large pumps, even though they do not have complete data, report that they are pleased with the results accomplished to date. The over-all cost of operating large pumps is more than the cost of operating small pumps, but the advantages of the large pumps, such as an increase in the drilling rate and usually an increase in footage per bit, greatly outweigh the added cost.

Application

1. Select liner size and pump speed to provide an adequate annular return velocity.

2. Utilize all the hydraulic horsepower available for circulation, above that needed for the annular velocity requirement, to increase the pressure differential across the bit nozzles. This increase in the energy of the fluid jet stream is accomplished by using the smallest size bit nozzles that the available horsepower will permit. The size of the bit nozzles must be increased as drilling progresses deeper, because the pressure losses inside of the drill stem increase with depth.

3. Some of the limiting factors in the application of this principle, other than the horsepower capacity of the pump, are the maximum pressure the operator wishes to place on the surface equipment and drill pipe, and the maximum pressure drop that the bit and nozzles are able to withstand without washing out.

Conclusions

Power pumps in the 700 hydraulic horsepower class satisfy present requirements for deep drilling, and are effecting economies by reducing drilling time at all depths. It is possible that most operators in the Gulf Coast area using pumps of this size are not taking full advantage of the principle mentioned in this paper. A very careful study of all the factors involved, such as liner size, volume of mud circulated, pressure losses, and bit nozzle size, is important to obtain all the potential advantages of large pumps, and the operators bothering to make such studies will be rewarded by lower drilling costs.

☆ ☆ ☆

Oil Company Fellowships

University of Texas geology students are recipients this year of four oil company fellowships, Dr. S. P. Ellison, geology department chairman, announced. Cecil Rix of Port Arthur has been awarded a $1500 Shell Petroleum fellowship; C. Stanley Wimberly, Humble grant, $1200; William N. McAnulty, $1250 Standard of Texas; and Daniel N. Miller, Stanolind Oil, $1250.

Acknowledgment

Part of the information used in this paper was taken from a paper presented by the author at the Shreveport meeting of the Southwestern District, American Petroleum Institute, March 5-6, 1952.

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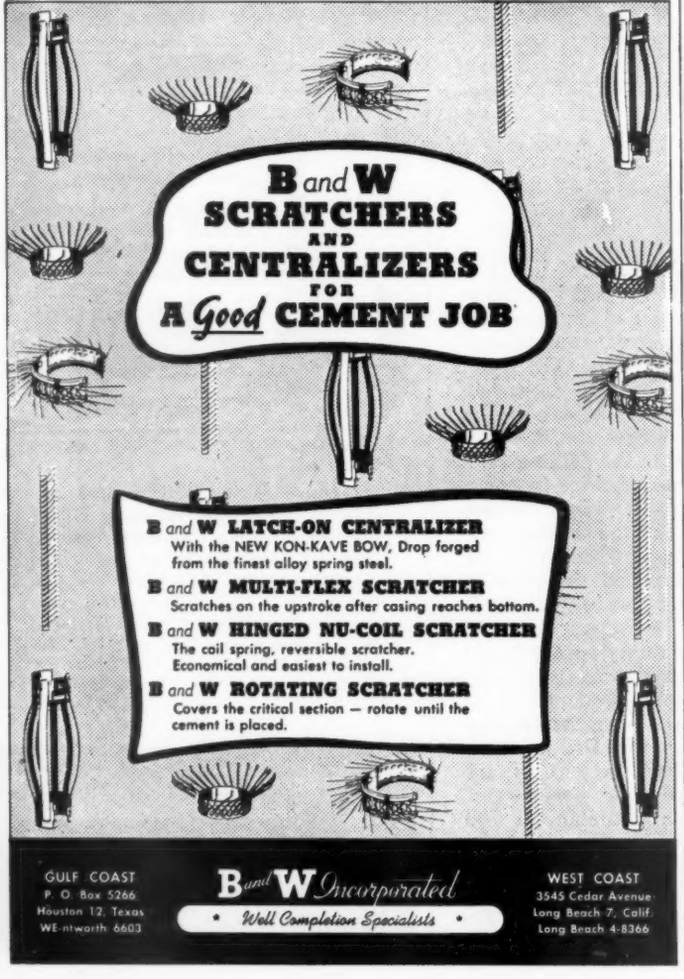
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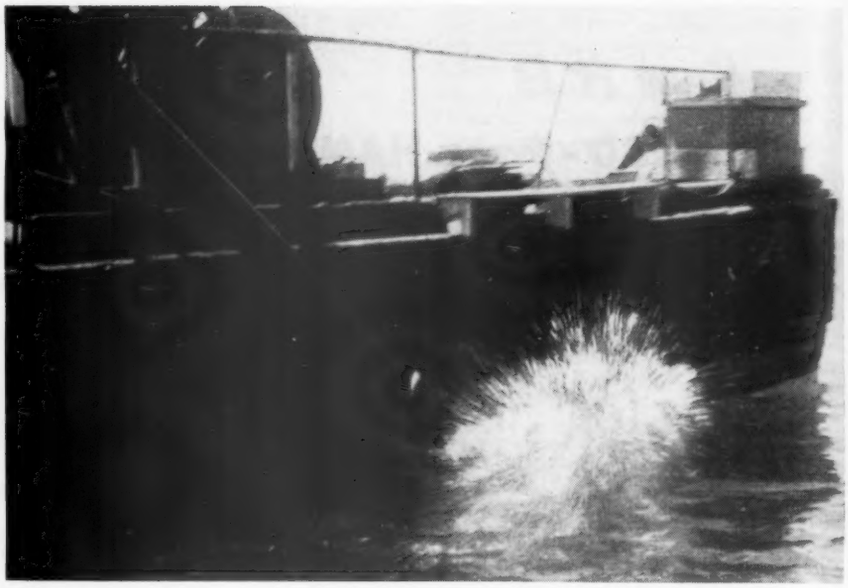
This is the jetting spoon used to bury charges under the ocean floor when surveying in shallow waters.



The jetting spoon is just being dropped into the water. By means of hydraulic power it will drill a hole in the ocean bed, at least 15 ft deep, and deposit the charge.

Offshore Surveys Excite Oil Operators

New seismic techniques save marine life as California operators get set for drilling plunge in Pacific waters

RICHARD SNEDDON*

BEGINNING in February of this year, that part of the continental shelf which lies off the shore of Southern California, from Santa Barbara to Los Angeles, has been subjected to almost continuous seismographic survey, and there is every likelihood that the work will go on for some time to come. Western oil operators, with their usual flair for advance planning, seem determined to examine all prospective sources of future oil supply now, regardless of the restrictions that may be imposed, and so prepare themselves as far as possible for the marine drilling era that must inevitably come to California. There are those, indeed, who will tell you that it is already here, and with Monterey Oil Company about to build a drill site one and half miles oceanward from Seal Beach, in water that is 52 ft deep, the contention would seem to be quite rational.

Standard Oil Company of California, General Petroleum Corporation, and Humble Oil and Refining Company are joint sponsors of the present survey which is being carried on, under contract, by Western Geophysical Company of America. This, of course, is not the first time offshore seismic work has been done in California, but it is the first time such a survey has been carried on with the use of self-orienting seismometers.

One of the most persistently voiced objections to offshore seismic surveys has been the public contention that the employment of explosives is highly destructive of marine life. Even at its worst, this was never the serious matter that some debaters maintained, and now, with the introduction of slow burning black powder, it is no longer even a problem. As for the new-type seismometers, they are so constructed that they remain always in the horizontal position; hence they catch the upcoming energy waves with maximum intensity and greatly improved uniformity.

EXCLUSIVE

Henry Ewald, of the Santa Barbara News Press, was, as he himself stated, "one of the severest critics of this blasting business;" but Henry Minturn of Humble, and Curtis Johnson of General Petroleum took him out one day to let him observe the operations at first hand, and here are some of the remarks he made in print after it was all over. "After each blast two divers were sent down to the bottom to roam the ocean floor in search of dead fish. Not one was found. I scanned the surface of the water very carefully and can truthfully say that not one single, solitary dead fish was seen. That is the truth, so help me. I wouldn't have believed it had I not been a witness to the operation." It should be added that all this took place in the presence and under the supervision of a representative of the California Department of Fish and Game, who had first satisfied himself that there was a normal plentitude of live fish in the vicinity.

The floated seismometer L spread has

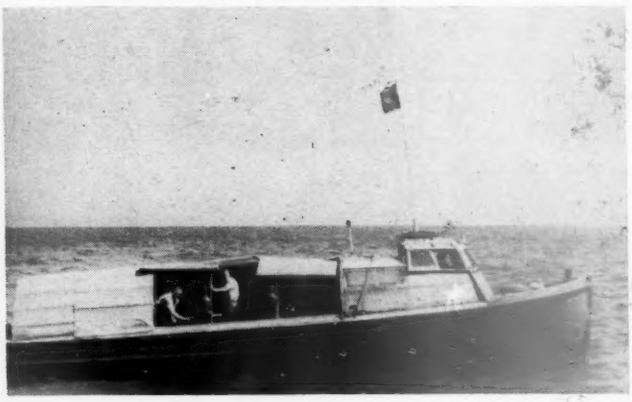
*Pacific Coast editor.

This shows the boil that immediately follows the discharge of a jetted shot.

The shooting boat crew picks up a marker buoy, used to designate the exact location of a jetted charge.

Here John Brustad, Western Geophysical Company, performs some of the calculations.

Interior view of the shooting boat.



Exterior view of the shooting boat.

been used in this survey with the seismometers gimbal-mounted in streamlined cases, thus permitting them to be towed through kelp or other obstructing media with the minimum of friction — hence the least possible effect on the instruments. The seismometers are immersed to a depth of approximately 10 ft, and the cable is supported by seine floats with marker or finger buoys at appropriate, easily visible locations to aid the surveyor in his observations.

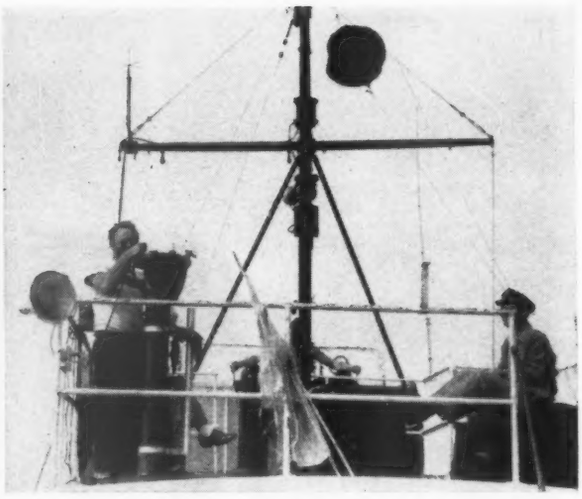
It seems to be generally recognized that the geology of offshore areas in California is quite complex and that dips are frequently steep. It is for this reason that the L spread is employed. The modus, normally, is to set two seismometer cables, one in the direction of the seismic line, and the other at right angles to it. Two tail boats hang on to the ends of these cables while the junction at the tip of the angle is held by the control boat. When the shot is fired, two dip components are recorded, which, of course, helps to make the final interpretation more positive and to rule out any anomalous reflections that may tend to complicate the picture.

Operations have been proceeding at

The blaster, aboard the shooting boat has just fired another charge. When all goes well, open water shooting can be carried on at the rate of one shot every three minutes.

An open water shot, usually fired about 6 ft below the surface of the water.

Shoran operator checks the position of the control boat by radar.



Surveyor sighting from weather bridge of control boat.

Recording instrument in operation aboard the control boat.

Skipper is here seen jockeying the control boat into position.

the rate of about 70 shots a day, although under ideal conditions it is possible to shoot as high as 160 shots a day (one every three minutes). When in open water, a 90-lb charge of the specially prepared black powder is used. This is detonated approximately six feet below the surface of the water. When close to shore or in shallow water, a smaller charge, about 40 lb, is jetted into the ocean floor to a depth of not less than 15 ft. The decision in these matters rests with the representative of California Fish and Game Commission, who is consulted prior to each shot.

The jetting operation necessitates the addition of a special jetting boat to the normal seismographic fleet. This unit is equipped with the machinery and essentials required to jet a 40-lb charge of explosive to the requisite depth under the ocean bed. It consists mainly of a cylindrical jetting spoon in which the charge, packed in cylindrical cans is placed. Sea water is then pumped at high velocity through the spoon, and as it emerges, picks up a circular motion which literally drills a hole into the mud or sand at the bottom of the sea. When the hole is deep enough, the charge is dropped from the spoon, is held in place by barbs or anchors, and the spoon is then withdrawn. Exact location of the charge is marked by a captive buoy.

A shooting boat makes up the charges, carries them to the spot where they are to be placed, and fires them when the time arrives for that. Powder is received in 45-lb cans, and for an open water shot, two cans are tied together, the fuse is attached, and so also is the shot-firing line. A balloon with sufficient line to keep the charge submerged at the prescribed depth (usually 6 ft) is tied on, and the entire assembly is placed in a chute. When the boat arrives at the shooting location, as determined by the surveyor, the bottom of the chute is opened and the charge is dropped into the water. When all is clear and everyone concerned has been apprised of the impending event, the surveyor then gives a signal and the charge is detonated.

The electrical impulse that fires the shot is relayed to the recording instruments aboard the control boat by radio, and the fact and the instant of its occurrence become an important part of the record. It is to be noted that every safety precaution is taken in the handling of the explosives. No one, except the shooter, can explode the charge. The blaster by itself is inoperative and can only be actuated by a mechanism of which the shooter has entire control. While there is a charge on the shooting boat, all radio equipment is turned off. Incidentally, by keeping the shooting boat farther offshore and using gap spreads, it has been possible to cover areas sufficiently close to shore to cut the use of jetting to a minimum. Since the latter is a slow and costly process, this is a "consummation devoutly to be wished."

The control boat is, of course, the master unit of the fleet. Besides having the recording instruments aboard, this craft tows the cables with the seismometers to each new firing site, and eventually directs each operation. It has

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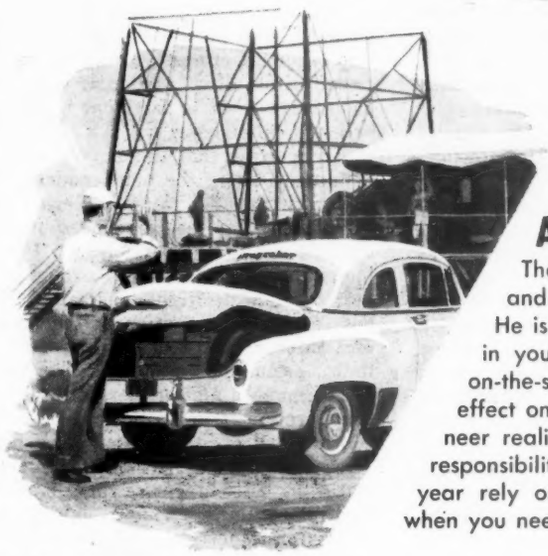

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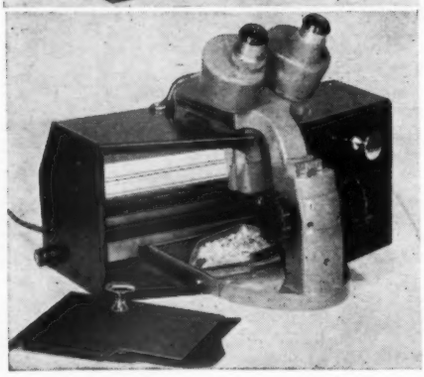

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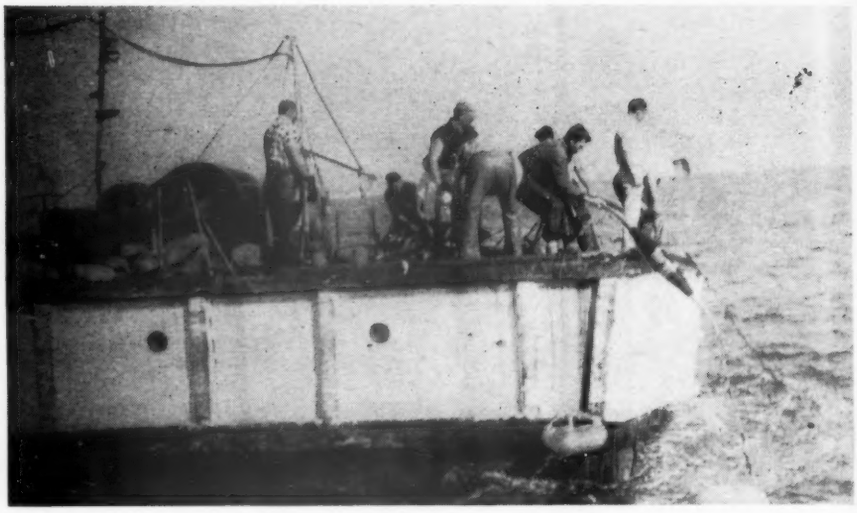

Hauling the seismometer cable aboard, with one of the seismometers coming in.

aboard, location finding instruments, the Shoran-radar system, and is living quarters for most of the survey party. From this unit all location surveying is done, using a gyro repeater compass for sighting the marking buoys, and the seismic records are received, developed, and printed.

Immediately following every shot, the representative of the California Fish and Game Commission moves in to inspect the boil. At the same time a fathometer is used to determine the accurate ocean depth at the shot point, and when the records are complete, each day's accumulation is taken to Santa Barbara where an interpretation department, consisting of seventeen men, with an assortment of special mathematical devices and machines, examines the medley of energy waves meticulously, and translates its observations into pertinent information.

Even with the most accurate surveying instruments and aids, the business of pinpointing shot location and determining the precise position and direction of the seismometer cables is not a simple procedure. The surface of the ocean is by no means a static plane, and holding an exact position imposes some pretty stringent requirements even on the navigators. As in most operations, however, familiarity develops understanding, and the operators become peculiarly adept at their various tasks. The surveyor for example, becomes amazingly expert at predicting positional changes in the seismometer cables with every change in position of the tail boats or the control boat.

Surveying, as might be imagined, was a vastly more difficult process before the advent of Shoran, and, needless to say, decidedly more uncertain. The California sea bed drops off quite sharply from the shoreline, and seismic work consequently is carried on in reasonable proximity to the shore (4 to 10 mi). When the sextant and gyro compass were the sole means of location and direction, good results were frequently precluded by foggy weather and poor visibility, and much work time was consequently lost. Shoran, an electronic system, similar to radar, is quite independent of visibility, and is hence ideal for use in the frequently hazy California offshore areas.

It has been reported by prior observers that the interpretation of these offshore seismograms in California is complicated sometimes by mutiple energy bursts when the shot has been placed too deep and the so-called "bubble" effect is produced. Similarly, the results are occasionally confused by the presence of apparently extraneous or anomalous effects that to the inexperienced might be pretty difficult to explain. The seismologists, however, like an other operators, soon learn the peculiarities of a particular area, and soon learn what is pertinent in the record and what isn't

It is certain that this survey is being conducted along the most modern lines and with the last word in devices and equipment. The sea-going personnel, including about 25 boatmen and 10 seismological people, are all thoroughly experienced in this highly specialized business and the acquisition of the records and interpretation of results, with all their attendant essentials; although pretty much a matter of routine by this time, are still stimulating practices that continue to excite the scientific mind. There is actually nothing completely static in an enterprise of this kind. Equipment improvement, method adaptation, and increase of personal skills are the normal concomitant of continued experience, and the result is that the entire process becomes more and more valuable as time progresses.

Western Geophysical is at the moment carrying on this offshore survey under contract to Standard of California, General Petroleum Corporation, and Humble Oil and Refining Company. Other west coast oil organizations are contemplating similar joint action, and there is every evidence that the California coastal waters are going to be the scene of intense activity — both exploratory and exploitative—during the next few years. ★ ★ ★

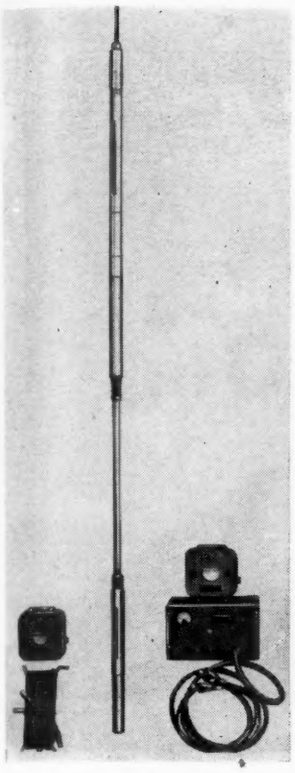

FIG. 1

FIG. 2

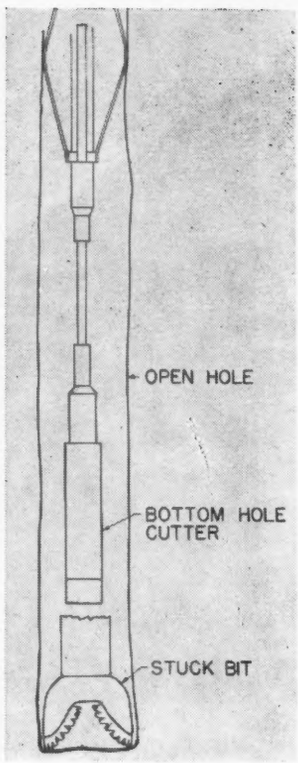

FIG. 3

FIG. 1. Magna-Tector, key progressive tool, is an electronic device, which accurately locates stuck point in drill pipe, casing, or tubing in minutes.

FIG. 2. Double acting rotary jar has simple sturdy construction of jarring elements.

FIG. 3. New jet bottom hole cutter positioned directly above stuck bit in bottom of well.

What the Service Company Contributes to Deep Drilling

Tools that take the hazard out of deep drilling have had much to do with its increasing success

W. C. "HUT" ERWIN

SELDOM, if ever, is a well drilled today without the help of that most essential segment of the industry—the oil tool service company. These service companies, which provide specialized oil well tools and experienced crews to run them, have come into existence within the last twenty-five years. From the beginning they have played an important role in the progress of the oil industry.

W. C. "Hut" Erwin, western division general manager, McCullough Tool Company.

The birth of the oil tool service company was a natural development that filled a long felt need. In earlier days, the oil tool firms manufactured their products for sale directly to the oil companies. Each oil company, in turn, maintained tool houses heavily stocked with numerous types of fishing tools. Many of these tools were designed by the driller to meet an immediate need. In those days a typical recommended list of fishing tools for just one rig included over 40 different items.

Most of the tools were of non-standard design and seldom were cataloged. One department within a company lacked knowledge of the tools another department possessed. Free exchange of tools between different oil companies was a rarity.

Being aware of these conditions, and desiring to do something about it, a number of enterprising oil men formed companies, outfitted shops, set up service departments, issued catalogs, obtained competent operating personnel, and offered their specialized services to the industry.

This infant business of oil well service soon became a boon to the oil companies. Costly inventories of seldom used tools were reduced. Machine shops and personnel for maintenance and repair were no longer needed. Taxes on these properties were eliminated. The expense of training men to specially operate the various types of tools which were rarely used was likewise eliminated. Tools and services were made available at nominal rental or service rates, in contrast to the previous high cost of outright purchase of tools.

The new service organizations, under the healthful pressure of competition, developed better devices and techniques than had ever before been known. Skilled engineers and scientists possessing inventive tendencies were attracted to their plants. Many of the oil industry's most capable men joined the service companies and offered their priceless experience and know-how to the development of new tools. By and large, the key personnel of most oil tool service companies today are oil men. The men working at the lathes in an oil tool service shop are referred to not merely as "machinists," but rather as "oil tool machinists." Their background of experience explains the difference.

Over the years, millions have been spent in research and development, and as a result, much of the technological progress of the oil industry has been brought about by the service companies. Today their activities comprise practically all of the applied sciences — metallurgy, chemistry, explosives, and the newer science of electronics.

The end result has been the birth of a new line of oil well tools that eliminates the need of fishing in certain cases, and in most cases any fishing that might be necessary is greatly simplified and speeded.

But these new tools are not fishing tools. Instead they could be more aptly called "progressive tools," since their use permits a quick return to drilling progress after trouble occurs. In many cases they solve the problem before it can get out of control, reducing fishing time from weeks or months to only a few hours.

Unlike fishing tools, these new progressive tools are fast. They are run into

EXCLUSIVE

the well on an electric wire line. Unlike fishing tools, they are controlled electronically, permitting intelligence of their activities to be received at the surface instantly. Unlike fishing tools, they get the job done by means of electromagnets or explosives.

Progressive tools are a development of my own company. Most of the tools are relatively new. Being new, their acceptance by experienced oil men had to be gained by actually proving their worth in hundreds of wells in every major oil field. Through the use of these new tools, wells have been saved that formerly would have been lost, due to the lack of the right tool or tools to get the job done.

There are three major progressive tools used in deep drilling operations:

1. Magna-Tector.

An electronic-electromagnetic device that accurately and quickly locates the stuck point in drill pipe, drill collars, casing, liners, tubing, or wash pipe.

2. String shot back-off.

Permits recovery of all free pipe without cutting damage. Used immediately after the Magna-Tector has located the stuck point.

3. Bottom hole jet cutter.

Quickly fragmentizes or destroys articles in the bottom of the well which are obstructing drilling progress. Such articles as reamer bodies, rock bits, slips, etc., which are broken up into small pieces, simplifying recovery.

All three of these tools have been used in the same well at one time or another. For example, the bit is lost at 11,700 ft. While pulling the drill pipe it sticks somewhere in the hole. The Magna-Tector is used to locate the stuck point. The string shot backs off a tool joint above the stuck point. All free pipe is recovered. Additional sections of pipe are recovered by washing over and backing off at points indicated by the Magna-Tector to be free. All remaining pipe is removed. With the bit left in the hole, and its recovery problematical, the bottom hole jet cutter is used to fragmentize it, simplifying its recovery.

When you compare the short time consumed by the use of these electric wire line tools with the round trip time consumed using mechanical cutters run in on drill pipe or tubing and guessing at the stuck point—days, weeks, and even months are saved. In the case of lost objects such as bits, reamer bodies, etc., that resisted all efforts to be retrieved, loss of the hole resulted, or whipstocking was necessary, both of which can now be eliminated in most instances by the use of the bottom hole jet cutter.

Of course there are tools developed by the service companies that help prevent such trouble while drilling. Of particular importance in deep drilling is the use of the double acting rotary jar in the drilling string. At the first sign of sticking, the jar can be actuated to strike blows both up or down at the will of the operator, freeing the string before more serious trouble occurs. The use of this tool has resulted in a sharp reduction in the number of fishing jobs formerly required.

In the past it seemed to most oil men that more time was spent fishing than drilling. But today, with drilling costs on a heavy rig between $40 to $50 an hour, the oil operator can't afford to waste rig time on something that doesn't make the hole any deeper.

That's why, when trouble occurs, he calls the service company with the equipment to do the job, and the fishermen who know their tackle. * * *

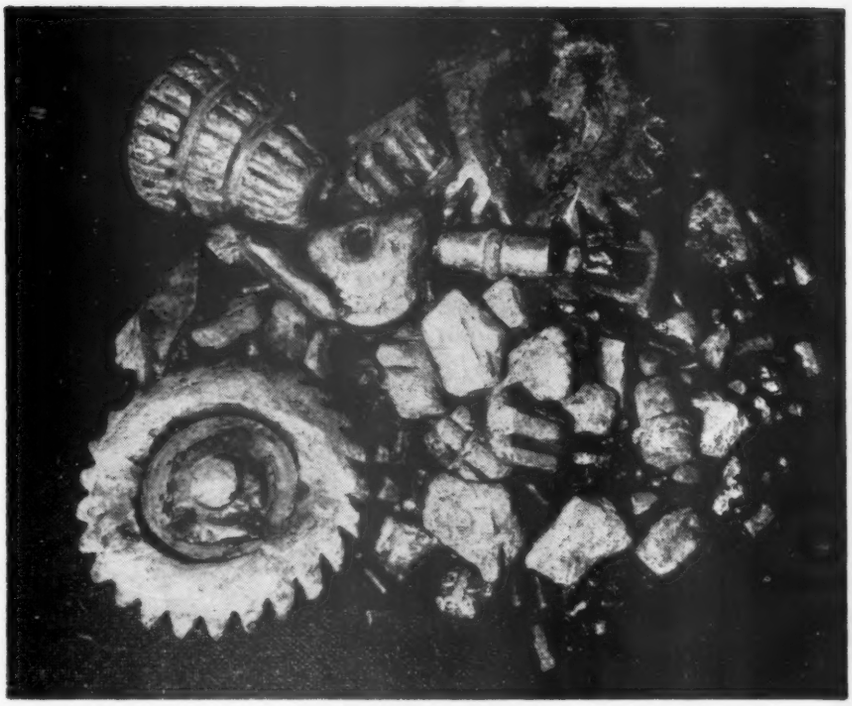

FIG. 4. Photograph showing recovered, fragmentized pieces of stuck bit after being shot by new McCullough jet bottom hole cutter.

☆ ☆ ☆

Knebel Makes Contribution Of Books, Papers to UT

G. Moses Knebel of New York City, University of Texas graduate and a Standard Oil Company of New Jersey executive, has made a large donation of books to the University's geology library in Austin, Texas.

Included are volumes on the geology of Egypt, other Near East areas, and Brazil, and professional papers and bulletins of various geological organizations.

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Mud Is Important Factor in Deep Drilling

G. O. WORLEY*

DURING 13 years of contract drilling in California, Rocky Mountain Drilling Company has drilled 33 wells to depths in excess of 12,000 ft. Twenty-one of these wells were bottomed at between 12,000 and 13,000 ft, 7 between 13,000 and 14,000 ft and 3 between 14,000 and 15,000 ft. One well was drilled to a depth of 17,696 ft.

Rocky Mountain Drilling Company's success in deep drilling can be attributed to a combination of good drilling practice and the use of the best equipment available.

Its drilling rigs work mainly in the California fields; nevertheless, each locality is different. Some of the problems encountered are extreme pressures, high temperatures, weak formations, sloughing shales, and various forms of contamination, such as highly contaminated water.

Drilling fluids play an important part in successful deep drilling. Rocky Mountain Drilling has its own mud engineer and he has done a great deal of research and development work on drilling fluids. To fulfill requirements these fluids must meet rigid specifications. Viscosity, gel strength, fluid loss, and weight are the essentials of good drilling fluids and need to be controlled rigidly.

Low viscosity mud washes and cleans the hole more thoroughly and helps to prevent the "swabbing action" usually encountered in small diameter deep holes. Low gel strength allows fast setting of silt and sand from the mud. A low fluid loss is essential to prevent the saturation of shale or weak formations. Wrong weight mud may cause much trouble, particularly when extreme gas and water pressures or sloughing shales are encountered.

In many instances, both high pressures and weak formations are present at the same time and require a perfectly balanced mud to prevent loss of circulation and simultaneous control of the high pressures.

One objective is to maintain a high annular velocity. When this is impossible, it becomes necessary to increase the gel strength, in order to suspend and carry the cuttings out of the hole. High gel strength increases pump pressures and reduces annular velocity, resulting in greater wear to the pumping equipment. High annular velocity, with low viscosity, permits increased pentration.

In some deep hole drilling Rocky Mountain has used a lime base emulsion mud. This mud has proved very successful. Lime base emulsion muds have many desirable characteristics, such as high weight, low fluid loss, low viscosity, and low gel strength. Although lime base emulsion mud has proved superior to other types of drilling fluids for over-all drilling, it still requires constant and intelligent supervision. * *

* Vice president in charge of contracts, Rocky Mountain Drilling Company.

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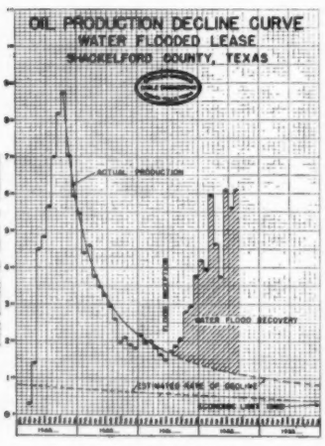

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Better Slush Pump Performance Is Possible

Saving many dollars can be achieved quite often in drilling operations by having a more effective hydraulic system

KENNETH N. MILLS

THE desire to improve drilling efficiency to partially offset increased costs has resulted in interest in the efficiency of the mud circulating system, because one of the keys to increasing the rate of pentration is increasing the hydraulic power available at the bottom of the hole. The relationship between the power available at the surface and at the bit is dependent on the hydraulic efficiency of the circulating system between these two points, and the power available at the bit can be increased by increasing the efficiency of the system. The efficiency of the system is influenced by the rate of circulation, the flow characteristics of the drilling mud, the size of the fluid passages and the mechanical characteristics of the slush pump drive.

The fact that the rate of penetration is related to the rate of drilling fluid circulation is not new, and it was known before the introduction of the jet type bit. One of the basic purposes of the drilling mud in the rotary drilling process is to remove cuttings from the hole. To accomplish this purpose the vertical velocity of the mud in the annulus between the drill pipe and the hole must be greater than the rate of fall of the cutting in the fluid. The theoretical considerations involved in the lifting of cuttings from the hole were defined by J. S. Piggott.[1] The rate at which cuttings are conveyed up the annulus by the mud is a function of mud velocity, mud viscosity, mud density, and the size and shape of the cuttings. In Piggott's paper, "Mud Flow in Drilling," he gives some tabular values of cutting slip velocity for two types of cuttings. One of these tables is shown in Table 1. In this table it will be noted that: Slip velocity increases as the size of the cutting increases, and it is higher for round cuttings than for flat cuttings. The slip velocity decreases as the mud viscosity or density is increased. If the cuttings are too large to be lifted at the velocities existing in the annulus, they must be recut by the bit until their size has been reduced sufficiently to permit them to be carried up by the mud stream. If the concentration of these large cuttings at the bit is too great, the bit will "ball up" and drilling progress will stop. This fact partially accounts for the extremely high rates of penetration obtained when jet bits are used in soft formation drilling. The fluid jet tends to disintegrate the cuttings, thus reducing their size and increasing the efficiency of the mud as a chip conveyor.

TABLE 1.

Mud velocity		Slip velocity of cutting ft/sec. Diameter of cutting-inches				
Ft. per min.	Ft. per sec.	0.50	0.25	0.125	0.063	0.031
		Round cuttings				
6	0.1	0.07	0.018	0.004	0.001	0.000
18	0.3	0.21	0.054	0.013	0.003	0.000
30	0.5	0.35	0.090	0.022	0.006	0.0015
60	1.0	0.70	0.180	0.044	0.011	0.003
120	2.0	1.39	0.350	0.086	0.022	0.006
180	3.0	1.85	0.510	0.130	0.032	0.008
240	4.0	1.85	0.670	0.170	0.042	0.011
360	6.0	1.85	0.960	0.240	0.060	0.015
		Flat cuttings				
6	0.1	0.027	0.007	0.002	0.000	0.000
18	0.3	0.081	0.021	0.005	0.000	0.000
30	0.5	0.135	0.035	0.008	0.002	0.000
60	1.0	0.270	0.070	0.017	0.004	0.001
120	2.0	0.540	0.140	0.033	0.008	0.002
180	3.0	0.720	0.200	0.048	0.012	0.003
240	4.0	0.720	0.270	0.065	0.016	0.004
360	6.0	0.720	0.380	0.094	0.023	0.006

The Author

Kenneth N. Mills received a BS degree in mechanical engineering from Rice Institute in 1933. After he graduated he joined American Manufacturing Company of Texas and became chief engineer of that company. In 1940 he joined Bethlehem Supply Company as chief engineer. During the war he became works manager for Texasteel Manufacturing Company and later assistant chief mechanical engineer of Emsco Derrick and Equipment Company at Houston. He joined Ideco as machinery products manager at Columbus in 1949. Recently he accepted the position of chief engineer with Walter O'Bannon Company, Tulsa, Oklahoma.

The above analysis does not consider the effect of jet bits in hard formation drilling. When drilling the harder formations, the high velocity fluid jet directed against the bottom of the hole helps lift the fresh cuttings from the bottom of the hole and inject them into the mud stream. Thus, these cuttings are removed from the path of the rock bit cutter before they are re-cut. This action assures a continuous presentation of virgin formation to the rock bit teeth and results in high drilling efficiency, because the bit is not required to re-drill its cuttings.

EXCLUSIVE

The problem of selecting an optimum return velocity to assure efficient removal of cuttings from the hole involves economic and practical considerations. Both the hydraulic horsepower and the circulating pressure increases as the return velocity is increased, and the advantages gained must be balanced against the increased cost and hazards resulting from increased circulating rates. Increasing the return velocity above some critical value may cause loss of mud to the formation. This loss will occur when the sum of the hydrostatic pressure of the mud column in the annulus plus the circulating pressure in the annulus equals the pressure required to inject mud into the formation. If a high pressure gas formation is being penetrated, this effective pressure may be just sufficient to prevent a blow-out. If this is the case, the effective pressure in the annulus will be reduced by an amount corresponding to the circulating pressure when the pumps are shut down, and as a result of this pressure loss, the well will attempt to blow-out. The obvious solution to this problem is to control the mud velocity and properties to assure a low pressure drop in the annulus. Experience has shown that a return velocity in the annulus ranging between 175 and 200 ft per minute will assure good results in most instances. When drilling hard formations where the maximum cutting size will be small, it can be assumed that lower return velocities will yield satisfactory results.

The return velocity is dependent on the rate of circulation and the area of the annulus. The return velocity for various hole and pipe sizes can be determined from the alignment chart shown in Fig. 1. The use of this chart is illustrated by the example shown on the chart. If the hole and pipe sizes are known, first draw a straight line through these points that will intersect the turning axis "x." A straight line from this point on the turning axis through the desired return velocity value will intersect the pump output scale "B" at the pump output value required for this return velocity.

From Fig. 1 it is apparent that for a given hole size, the rate of circulation required for a constant return velocity decreases as the size of the drill pipe is increased. This is an important rela-

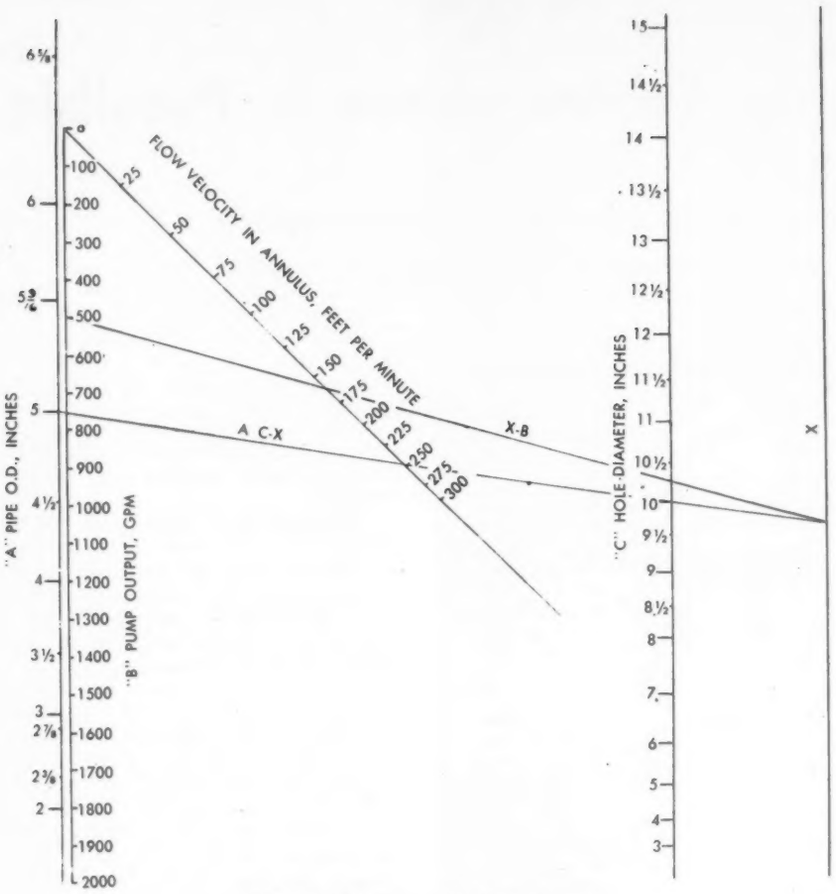

FIG. 1. Return velocity chart.

TABLE 2.

Pipe size, inch	Per cent increase or decrease in pressure drop over 4.5 in. pipe
3½—15.5 No. EUIF	620 Increase
4 —15.7 No. EUIF	220 Increase
4½—16.6 No. EUIF	
5 —19.5 No. IU	155 Decrease
5⅝—22.2 No. EUIF	320 Decrease

tionship influencing the over-all efficiency of the circulating system, because all the major pressure losses are a function of the rate of circulation. These losses decrease as the rate of circulation is decreased. The use of larger drill pipe has the additional value of materially reducing the magnitude of the pressure drop in the drill pipe. The magnitude of this savings, assuming 4½, 16.6 No. EUIF pipe as a standard and circulating at 500 gal per minute, is shown in Table 2.

The complete relationship between pressure drops and circulating rates for the various sizes and types of drill pipe are shown in Figs. 2 and 3. The same relationship for the annulus is shown in Fig. 4. The graphical presentations are based on the formulas developed by Beck, Nuss and Dunn[2] and are applicable to drilling muds whose properties approximate the values assumed in developing these data. Some of the effects of changing mud properties can be visualized by assuming that all properties except mud density remain constant. In this case the pressure drop will vary directly with mud density. For example if the mud weight is increased from 10 to 15 lb per gallon the pressure drop will

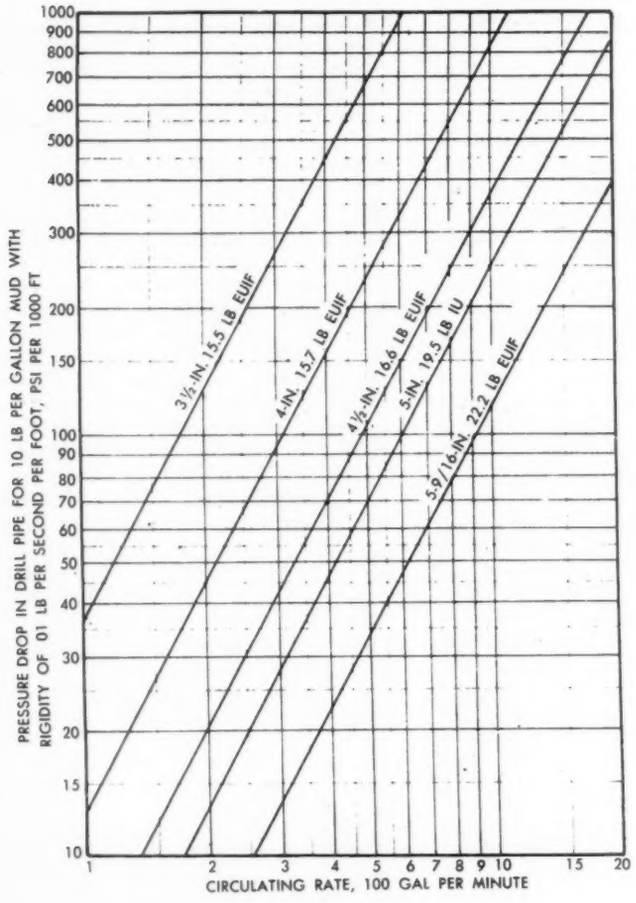
PRESSURE DROP IN DRILL PIPE FOR 10 LB PER GALLON MUD WITH RIGIDITY OF 01 LB PER SECOND PER FOOT, PSI PER 1000 FT
3½-IN. 15.5 LB EUIF
4-IN. 15.7 LB EUIF
4½-IN. 16.6 LB EUIF
5-IN. 19.5 LB IU
5.9/16-IN. 22.2 LB EUIF
CIRCULATING RATE, 100 GAL PER MINUTE

FIG. 2.

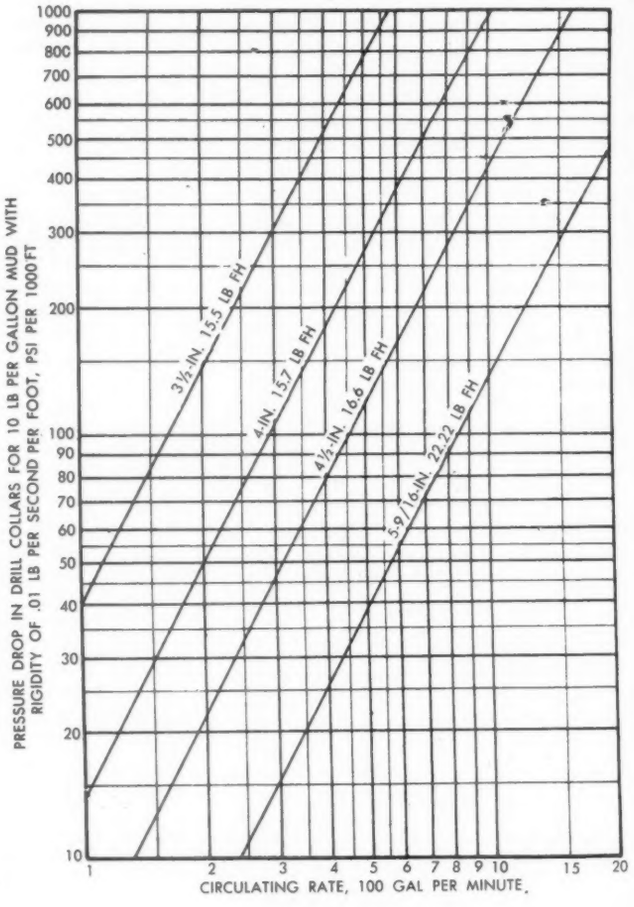
PRESSURE DROP IN DRILL COLLARS FOR 10 LB PER GALLON MUD WITH RIGIDITY OF .01 LB PER SECOND PER FOOT, PSI PER 1000 FT
3½-IN. 15.5 LB FH
4-IN. 15.7 LB FH
4½-IN. 16.6 LB FH
5.9/16-IN. 22.22 LB FH
CIRCULATING RATE, 100 GAL PER MINUTE.

FIG. 3.

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Cementrol Equipment was originated by Larkin for the purpose of protecting exposed low-pressure, permeable formations against contamination by cement. Thousands of successful applications have made it standard equipment for such service.

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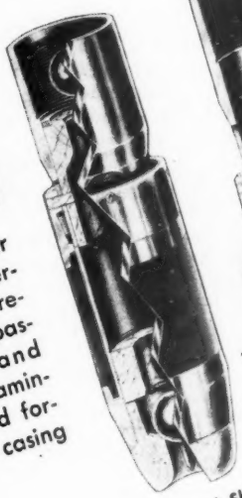
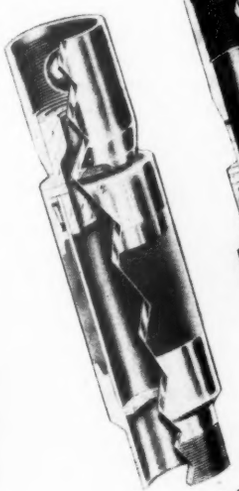


Cementrol Shoe Running-in Position

Cementrol Shoe in Pack-Off Position

CEMENTROL COLLAR

Operates just as Cementrol Shoe to direct slurry upwardly above perforated liners, formation crevices or other zones of lost circulation located at any point above casing seat.



Cementrol Collar Running-in Position

Cementrol Collar in Pack-Off Position

FLAPPER TYPE FLOAT COLLAR

Cementrol Equipment is hydraulically actuated by pump pressure. The Flapper Type Collar allows passage of bridging ball used in this operation.

Flapper-type Collar Floating-in Position

Flapper-type Collar Pumping Through

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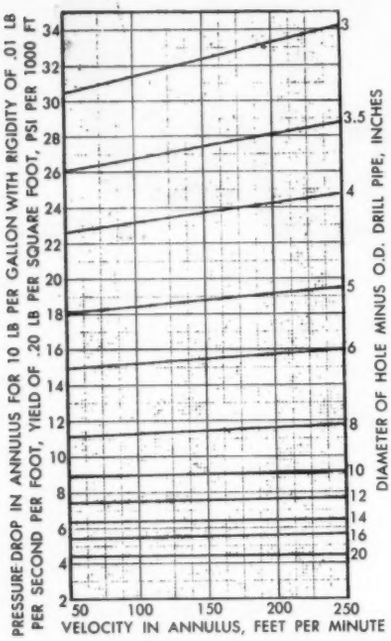


FIG. 4.

be 1.5 times the value shown on the charts.

The charts showing the relationship between drill pipe size and pressure drop indicate that large drill pipe had some distinct hydraulic advantages. These advantages are a function of hole size and increase as the hole size is increased. Naturally, the maximum drill pipe size is limited by fishing space, and this is the size limiting factor in many instances. In other instances the increased weight of the drillstem is a mental barrier, because it will reduce the hoisting speed. If the time lost in hoisting the heavier drillstem is compared to the improved drilling efficiency from increased hydraulic power at the bit, the lost hoisting time will usually appear insignificant. In addition to improving the rate of penetration, the increased hydraulic efficiency resulting from larger drill pipe will effect material reductions in fuel costs, and engine and pump maintenance, because it will reduce the amount of power required to circulate the drilling mud. The importance of considering hole size when selecting a drill pipe size is illustrated in Table 3. This table is based on drilling a 12-in. hole, 7000 ft deep with a constant return velocity of 175 ft per minute.

TABLE 3.

Drill pipe size	Circulating rate gpm	Input pressure psi	Input horsepower
4½	884	2140	1300
5	850	1350	790
5⅝	805	640	350

From this table the hydraulic advantages of larger drill pipe are immediately apparent. It will materially reduce the amount of power required for mud circulation. In reality it will increase the safe depth capacity of a drilling rig, if the power available is not sufficient to maintain a reasonable return velocity with smaller drill pipe. In the event the power available from the drilling rig is not sufficient to permit the use of jet bits and maintain a reasonable return velocity, the rate of penetration will be reduced and difficulty may be experienced with stuck drill pipe. The stuck drill pipe will be the result of insufficient return velocity in the annulus to move cutting through areas where the hole is enlarged. These enlarged areas will reduce the upward velocity of the mud, and consequently those cuttings whose slip velocity is greater than the fluid velocity in the enlarged section of the hole will be suspended in this area. When circulation is stopped, these cuttings will settle into a smaller section of the hole. If the concentration of these cuttings is sufficiently great, they can cause the pipe to become stuck.

The advantages of using large area pipe are not limited to the drillstem, because relatively large power losses can occur between the slush pump and drill pipe. The variation of pressure drop with rate of circulation for two surface piping systems is shown in Fig. 5. These circulating systems are composed of the following elements:

System A
- Pump to hose—100 ft 3½-in OD pipe
- Hose—45 ft 2½-in. ID
- Kelley—40 ft 2¼-in. ID
- Swivel—4 ft 2-in. ID

System B
- Pump to hose—100 ft 4½-in. OD pipe
- Hose—55 ft 3-in. ID
- Kelley—40 ft 3¼-in. ID
- Swivel—5 ft 2½-in. ID

The hydraulic advantages of the large area assembly are apparent and increase as the rate of circulation is increased. This analysis does not recognize the adverse effect of the pressure drop created by fittings, and the number of fittings should be kept at a minimum, because an ell can create a pressure drop equal to several feet of pipe. When it is necessary to use fittings in the piping system, they should be of the long radius type, and all valves should be the straight flow through type. The number of fittings in this phase of the circulating system can be reduced by using a discharge hose between the slush pump, and the manifold. This has the additional advantages of reducing rig-up time and relieving the manifold of unnecessary stresses due to pump vibrations and settling.

As the pump efficiency is influenced by the hydraulic characteristics of the suction system, its design must be considered if maximum efficiency is expected. Pressure losses in this phase of the circulating system add to the power required to drive the pump and can adversely affect its fluid output. To assure efficiency the suction lift and length of the suction piping should be kept at a

FIG. 6.

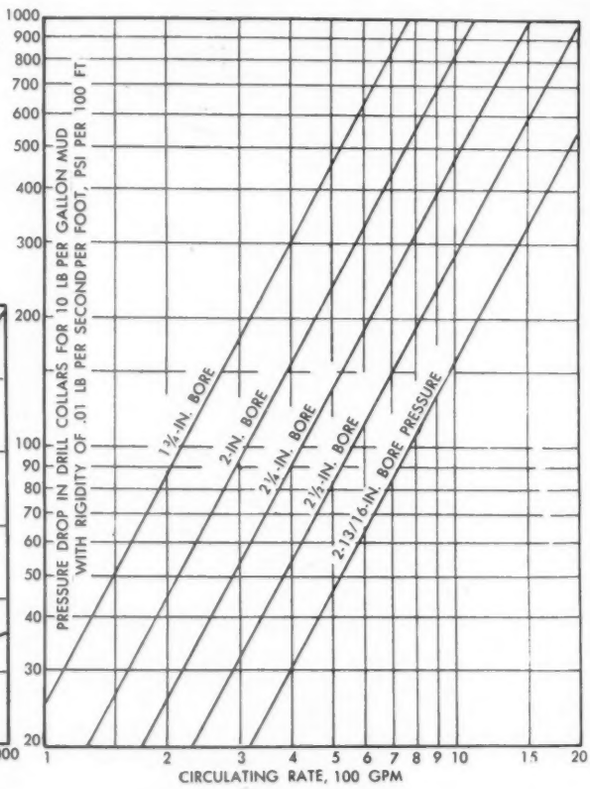
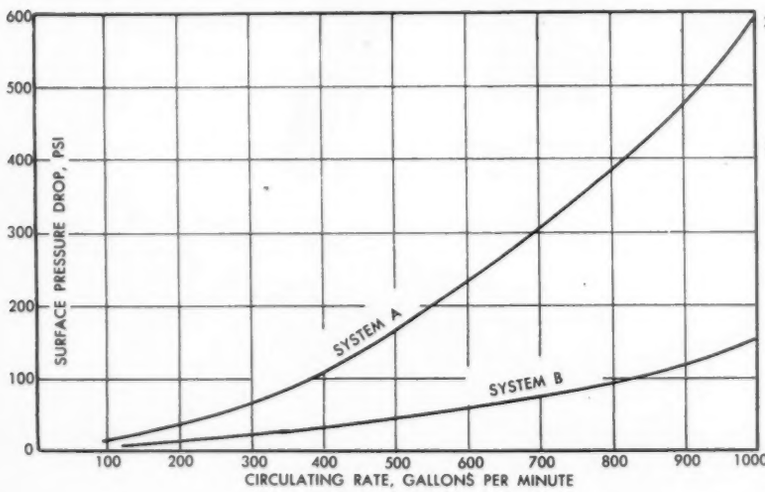

PRESSURE DROP IN DRILL COLLARS FOR 10 LB PER GALLON MUD WITH RIGIDITY OF .01 LB PER SECOND PER FOOT, PSI PER 100 FT
1¾-IN. BORE
2-IN. BORE
2¼-IN. BORE
2½-IN. BORE
2-13/16-IN. BORE PRESSURE
CIRCULATING RATE, 100 GPM

FIG. 5. ↓



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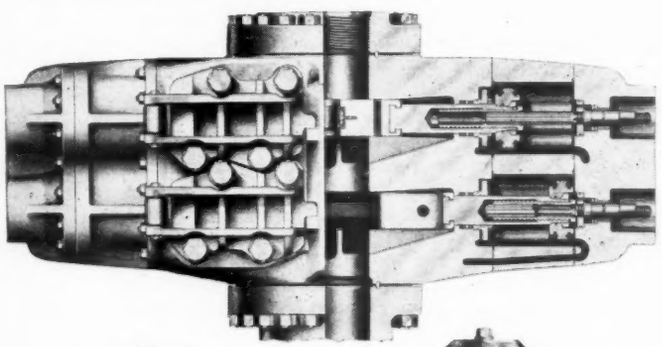

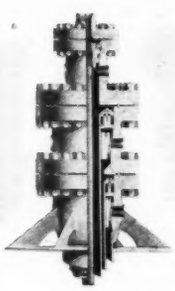

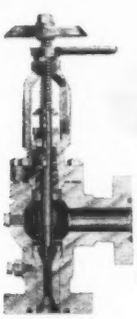

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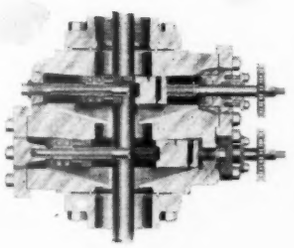

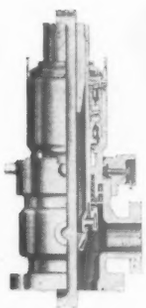

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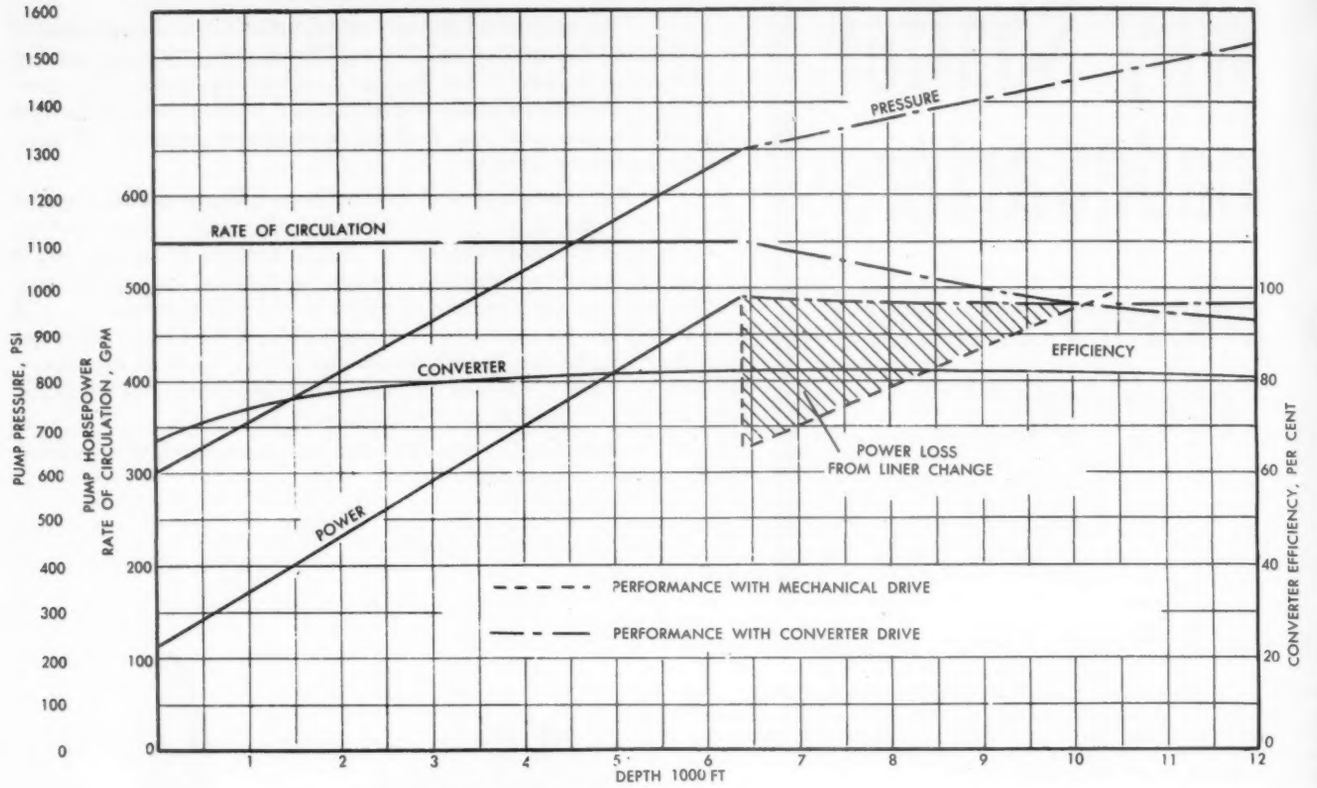


FIG. 7.

minimum, and the size of the suction piping or hose should be equal to the suction opening on the pump. The suction line should slope continuously to the mud pit, and it should not contain unnecessary bends as these add to the suction head.

The practice of using large numbers of drill collars has added to the power loads placed on the pump, and to assure reasonable hydraulic efficiency they should have large bores. The variation in pressure drop with circulating rate for several drill collar bore sizes is shown graphically in Fig. 6. The full importance of this pressure loss is illustrated by the fact that the pressure drop in 100 ft of drill collar with a 1¾-in. bore when circulating at the rate of 500 gpm is equal to that of approximately 4000 ft of 4½-in. EUIF drill pipe. If the drill collar bore is increased to 2½ in., the pressure drop is equal to that of approximately 750 ft of 4½-in. EUIF drill pipe. This indicates that small increases in drill collar bore will produce marked improvements in hydraulic efficiency. The fact that these improvements in hydraulic efficiency can be accomplished with minor reductions in drill collar weight is shown in Table 4, which is based on circulating at the rate of 500 gpm through 100 ft of drill collar.

TABLE 4.

Bore size	Pressure drop psi	Weight reduction per 100 ft with 1¾ as standard
1¾	460	0
2	240	250 lb
2¼	140	534 lb
2½	81	851 lb
2¹³⁄₁₆	47	1294 lb

The constant displacement characteristics of the conventional mechanically driven power slush pump are not ideally suited to the rotary drilling process. When drilling a constant hole size, it is desirable to maintain a constant rate of circulation to remove cuttings from the hole. This will impose a constantly increasing power load on the pump, because the circulating pressure, and consequently the rate of circulation must be reduced as drilling progresses to prevent overloading the pump and possibly the engines. When the liners are changed the return velocity is reduced, and consequently the ability of the mud to remove cuttings is reduced. For this reason

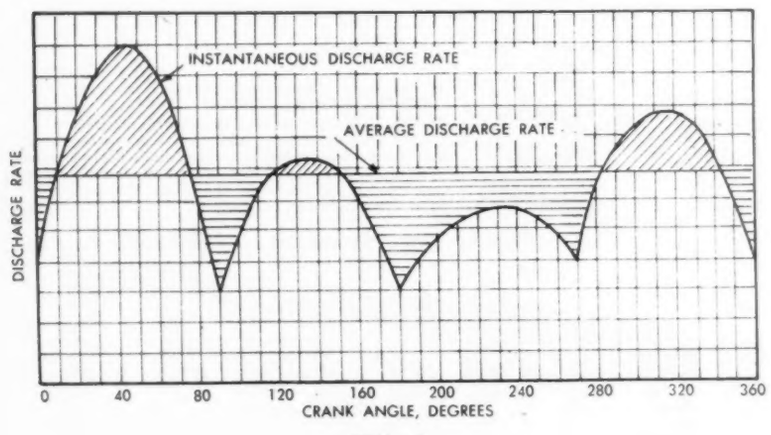


FIG. 8.

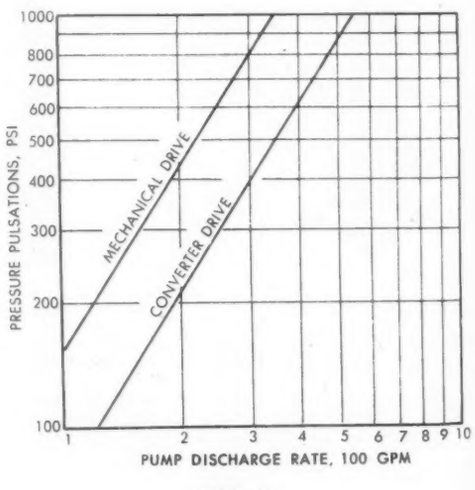
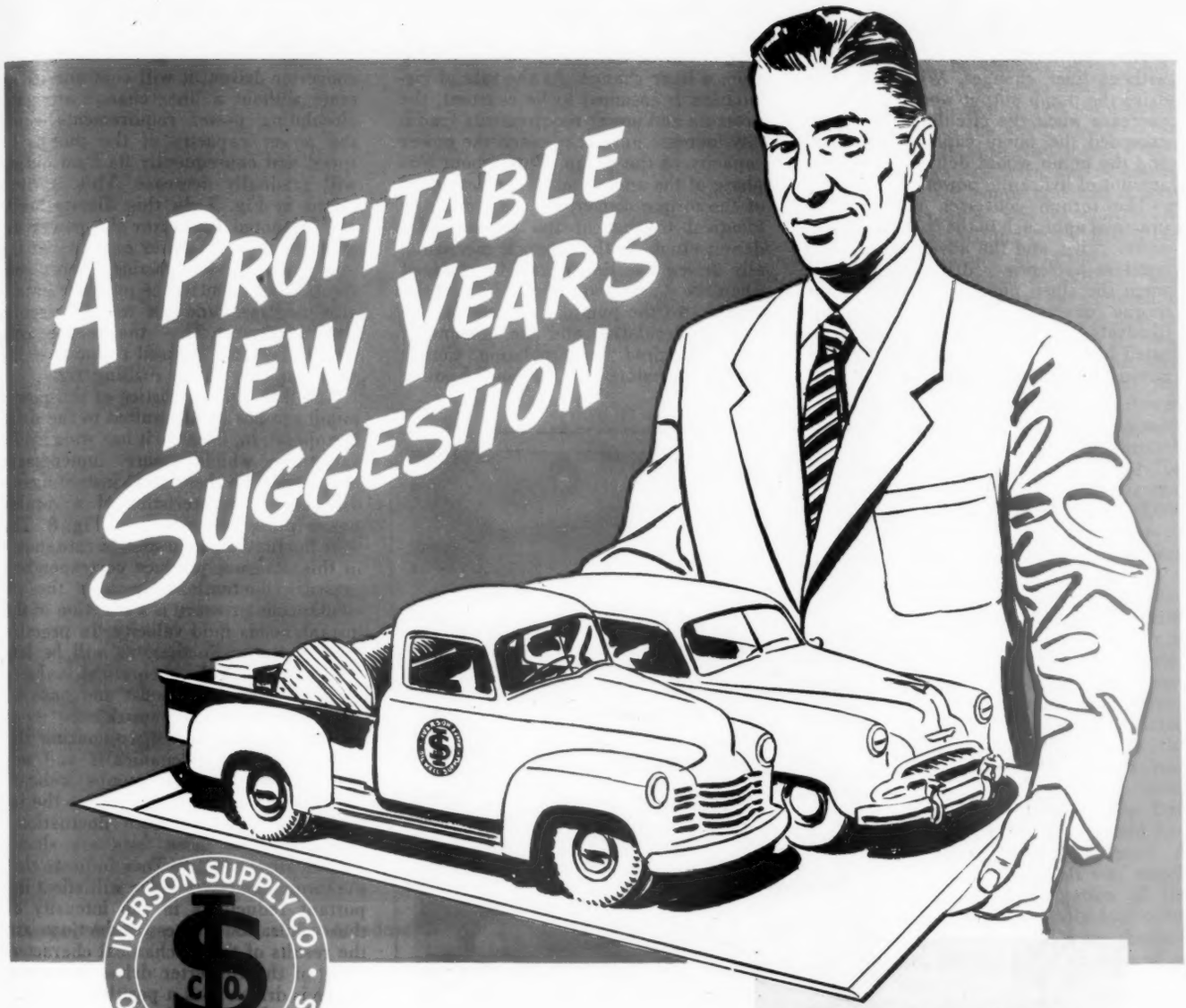


FIG. 9.



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the ideal mud pump drive would be a constant horsepower drive as it would permit continued operation of the pump without liner changes. With this type drive the pump output would gradually decrease when the circulating pressure exceeded the pump capacity pressure, and the pump would deliver a constant amount of hydraulic power.

The torque converter represents a practical approach to the constant horsepower drive, and the advantages of the constant horsepower drive are attained when the slush pump is driven with a torque converter. These advantages are illustrated in Fig. 7. This graph indicated how the circulating pressure and power and rate of circulation vary with depth when the mud pump is driven with a torque converter. Also, it shows the magnitude of the power loss resulting from a liner change. As the rate of circulation is assumed to be constant, the pressure and power requirements gradually increase until they reach the power capacity of the pump. Throughout this phase of the operation, the performance of the torque converter driven pump is identical to that of the mechanically driven pump. If the pump is mechanically driven, the liners must be changed when the power requirements equal the capacity of the pump. This reduces the rate of circulation and the amount of power required for circulation. Consequently, it reduces the amount of power available for useful work. The magnitude of this power loss is indicated by the shaded area in Fig. 7. If the pump is converter driven, it will continue to operate without a liner change after the circulating power requirements equal the power capacity of the pump. Its speed and consequently its fluid output will gradually decrease. This is illustrated in Fig. 7. In this illustration it will be noted that after the power demand equals the power capacity of the pump, the power remains almost constant. Consequently, the pressure gradually increases, and the rate of circulation decreases. Thus the torque converter drive can be used to increase the work capacity of the drilling rig.

The flow characteristics of the power pump are not ideally suited to the drilling operation, because it has wide cyclic variations which create unnecessary pressures. The theoretical instantaneous discharge characteristics of a duplex power pump are shown in Fig. 8. The wide fluctuations in discharge rate shown in this diagram produce corresponding pressure fluctuations, because the instantaneous pressure is a function of the instantaneous fluid velocity. In practice these pressure fluctuations will be less severe than their theoretical values; however, they will persist and have an important effect on the work capacity of the pump. Field tests[3] comparing the performance of mechanically and torque converter driven pumps indicate that the torque drive will reduce the intensity of these pressure fluctuations. The results of these tests are shown graphically in Fig. 9. They indicate that the torque converter drive will effect important reductions in the intensity of these pulsations. These reductions are the results of the mechanical characteristics of the converter drive. When the pump is driven with a positive mechanical drive, the engine forces the pump to operate under conditions approximating a constant speed, and consequently its discharge characteristics follow the theoretical pattern. When the pump is driven with a torque converter, it tends to operate as a variable speed device, and it slows down when the load increases. As a result of this tendency to shirk the load, the flow characteristics of the pump are improved, and its ability to perform useful work is increased.

Additional reductions in the intensity of these discharge fluctuations can be achieved by fitting the discharge of the pump with a large volume accumulator. The pressure-volume characteristics of the accumulator must be such that it will store fluid during periods of high instantaneous fluid output and deliver this fluid to the system during periods of low instantaneous fluid delivery. This will result in a more uniform rate of fluid delivery and consequently reduce the maximum circulating pressure.

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2. "The Flow Properties of Drilling Muds," R. W. Beck, W. F. Nuss and T. H. Dunn, Drilling and Production Practices, 1947.
3. "Torque Converter Drives on Mud Pumps," D. F. Toomey and E. G. Chilton, Spring Meeting, Pacific Coast District API, Los Angeles, 1951.

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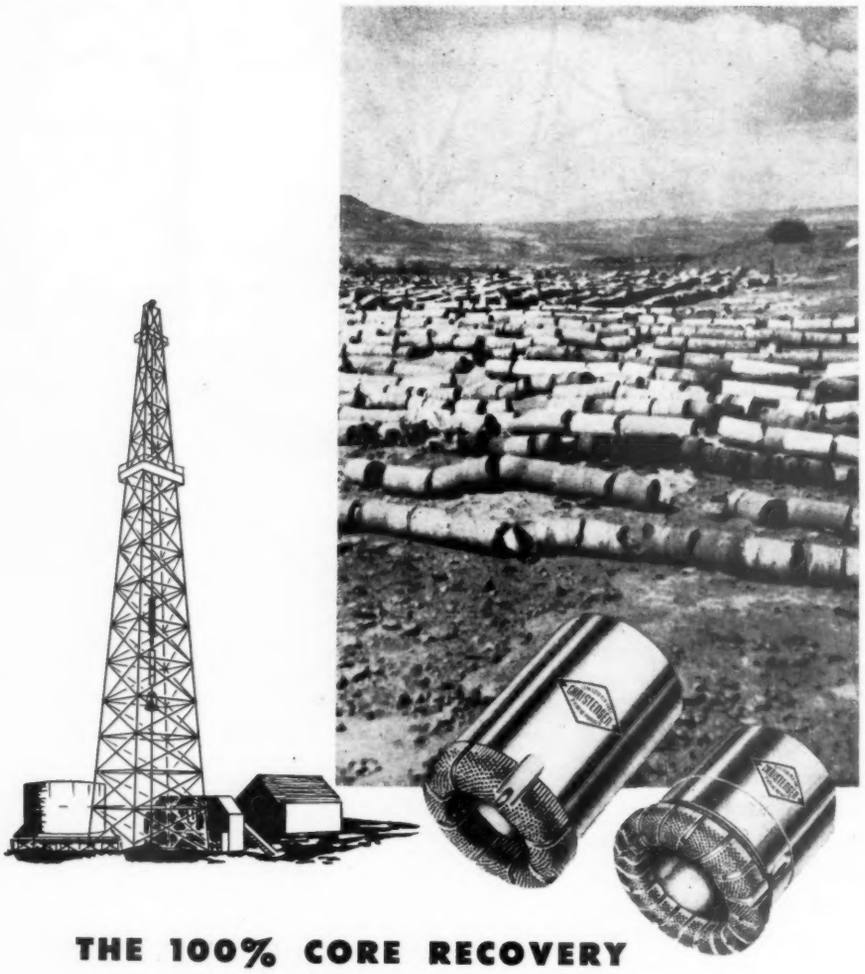

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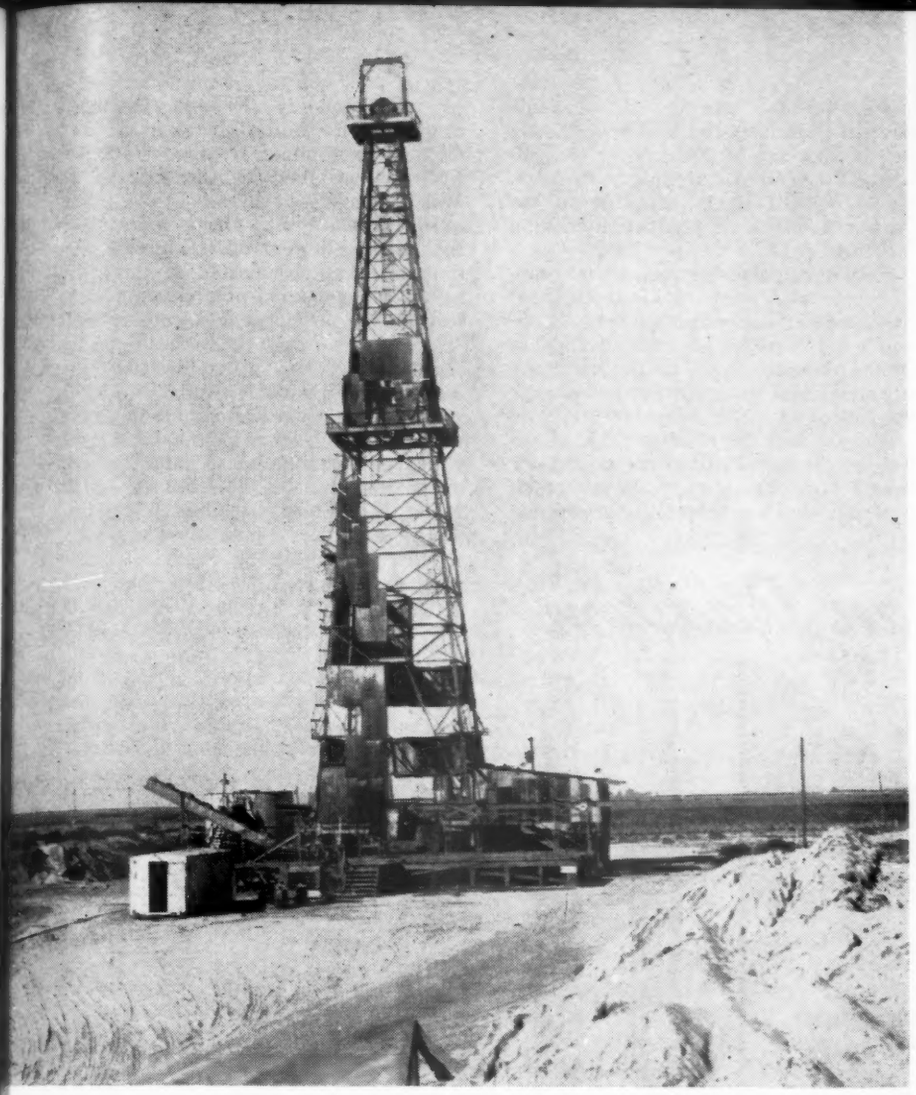

Deepest flowing production is from Standard of California Mushrush No. 5.

Does Deep Production Pay?

Mushrush 5, completed in the Eocene at Wasco three years ago presents interesting problem in deep drilling economics

WILLIAM T. RINTOUL

THE deepest producing well in California is Standard Oil Company of California's Mushrush No. 5 in the Wasco field five miles west of the town of Wasco in the Southern San Joaquin Valley. In September, 1949, Standard completed the 15,866-ft well flowing from perforations in the overall interval of 15,250-15,530 ft in the Eocene zone. Today, more than three years later, the deep well is still flowing high gravity oil.

At the time the well was completed, it was generally acknowledged to be the deepest producing well ever completed anywhere in the world. Other holes had gone deeper, but none had been completed from a greater depth. More recently, however, Shell Oil Company is reported to have developed production from an interval at 16,572-16,600 ft in a well in the Weeks Island field of Iberia Parish, Southern Louisiana. As far as California is concerned, the Mushrush well is still the deepest producer. The top of its producing interval occurs more than 1000 ft deeper than the lower limit of the producing interval in any other well in the state.

EXCLUSIVE

Originally the well was drilled in the spring and summer of 1940 as a development well for the Vedder sand on the 320-acre W. J. Mushrush lease. Co-ordinates for the well were, and of course still are, 510 ft south and 330 ft east from the center of Section 7, 27S-24E. In 83 days the drilling crews drilled the well to a total depth of 13,130 ft.

Vedder was topped at 13,072 ft and the base of the zone was encountered at 13,100 ft. Pipe cemented in the hole included 13⅜-in. casing at 1030 ft; 9⅝-in. casing at 8100 ft; and 6⅝-in. casing at 13,053 ft. On a potential test early in August 1940, the well flowed 34-gravity oil at a 3052 bbl-per-day rate, cutting 1.8 per cent. Flow was through a 34/64-in. bean, with pressures of 700 lb on the tubing and 650 lb on the casing. The well made gas at an 862,000 cu-ft-per-day rate. Open interval was at 13,056-13,129 ft. Shut in pressures were 1300 lb over 1300 lb.

In February, 1949, after production from Vedder horizon had been almost depleted and the well was producing at a non-commercial rate, the operator moved a steam rig, with company crews, back to the Mushrush lease to deepen the well in search of a deeper producing horizon. The objective zone was the Eocene, which had been proved productive at shallower depths in many fields in the San Joaquin Valley. Previously no well in the Wasco field had penetrated to this objective zone. A depth in excess of 15,000 ft was anticipated for thorough evaluation of the Eocene zone. Previously only four other wells in California had gone beyond that depth. All had been abandoned as dry holes.

Four months were required to deepen the old well 2736 ft from former total of 13,130 ft to the new total depth of 15,866 ft below the Eocene sand. Alternately drilling and coring, the hole passed through hard gray shale, hard sandstone, and hard gray sand.

Drilling was remarkably free of mishaps. Stuck drill pipe halted downward progress on two occasions—once at 15,012 ft and again at 15,866 ft. In both instances the pipe was recovered with a minimum of lost time. Indications that the well was on the right track in the search for new production came just below 15,000 ft when there were slight showings of oil and considerable gas. From that point on it was necessary to add barytes to the mud to control the gas.

After total depth was reached, some difficulty was encountered in running electric log to the bottom of the hole. On the third attempt, almost two weeks after the first try, electric log was successfully run to the bottom of the hole. Results were not regarded as entirely satisfactory and radio active markers were shot into the hole, after which electric log was rerun.

Four weeks after reaching total depth, crews hung 2899 ft of 4½-in. blank liner at 15,863 ft, set a retainer at 12,927 ft, and cemented the 4½-in.

liner lap with 50 sacks. After establishing water shut off at 12,941 ft, the operator cleaned out to bottom. After getting another water shut off at 15,695 ft, which ultimately concluded with completion of the deep well from 15,250-15,530 ft. Completion was from the following perforated intervals: 15,250-15,275 ft; 15,285-15,310 ft; 15,335-15,350 ft; 15,365-15,390 ft; 15,440-15,475 ft, and 15,495-15,530 ft.

Early in September, 1949, 2⅜-in. tubing was run to 15,449 ft and packer was set at 13,013 ft. The well was swabbed and it kicked over on September 5, flowing at a daily rate of 375 bbl of 40.1 gravity oil. Initial flow was through an 18/64-in. choke, with 825 lb tubing pressure and a gas-oil ratio of 3460. Several days later the well was flowing 330 bbl-per-day of 38.9-gravity oil, cutting 2.9 per cent, through a 16/64-in. choke, with 1150 lb pressure on the packer. It went on production making 1,161,000 cu ft of gas per day.

Rough calculations indicated a subsurface static pressure of about 7000 psig, a reservoir temperature of 312 F and a solution gas oil ratio of 1500 to 2000. Assuming a 30-lb gradient, the subsurface well pressure at an average production of 350 bbl-per-day would be 5442 psig and the resultant P.I. of the well would be 0.21 bbl per pound per square inch drawdown. S. P. I. correlation indicated a permeability magnitude of approximately 35 md. Produced crude gravity ranged between 37 and 44 deg. A nominal reserve of 100,000 bbl was assigned to the Eocene at Wasco pending further drilling.

In the more than three years since the deep well went on production, the operator has not reported anything unusual in the method of producing it. It has been regarded as just another well—admittedly deeper than others—but in most respects no different from any other deep producer.

From an economic standpoint, the well has not been a big money-maker. Cumulative production to date has been approximately 165,000 bbl of high gravity oil. Steady decline in production is apparent from a study of yearly figures: 27,028 bbl in 1949, when the well was on production less than four months; 62,012 bbl in 1950; 46,493 bbl in 1951; and an indicated 30,000 bbl in 1952.

During the six-month period from April to September of this year, the well produced 14,513 bbl of oil, with daily output dropping from an average of 92 bbl-per-day in April to an average of 70 bbl-per-day in September. Total daily gas output dropped from 499,000,000 cu ft in April to 412,000 cu ft in September, with a corresponding rise in gas-oil ratio from 5462 in April to 5877 in September. During this six-month period, the well was on production full time for five full months and nine-tenths of the time for one month. An average water cut for this period was 2.7 per cent.

Indications are that economical considerations may limit the pool's life under the present production practice before the depletion of the Eocene reservoir. Since completion of the deep Mushrush well, one other well on the same lease has been deepened to the Eocene zone and it was abandoned as a dry hole. The operator is believed to have spent as much as $500.000 in deepening Mushrush No. 2, one-half mile southeast of the deep producing well, from former total depth of 13,125 ft, at which depth the Vedder sand was exhausted. to a new total depth of 15,550 ft. Showings encountered by this well were regarded as even better than those found by the well that was completed in the Eocene zone. Exhaustive efforts to complete the well failed, however, after testing by stages and even going so far as to put the well on the pump, the operator finally abandoned it.

At the present time, there is no indication that any further development of the Eocene zone is anticipated for the Wasco field. ★ ★ ★

Until 1952, when Pure Oil brought in West Poison Spider No. 3 in Natrona County, Wyoming, Standard of California Mushrush No. 5 had been the deepest producer in the world. See story on page B-9.

In the American Tradition

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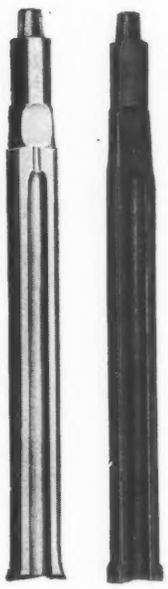

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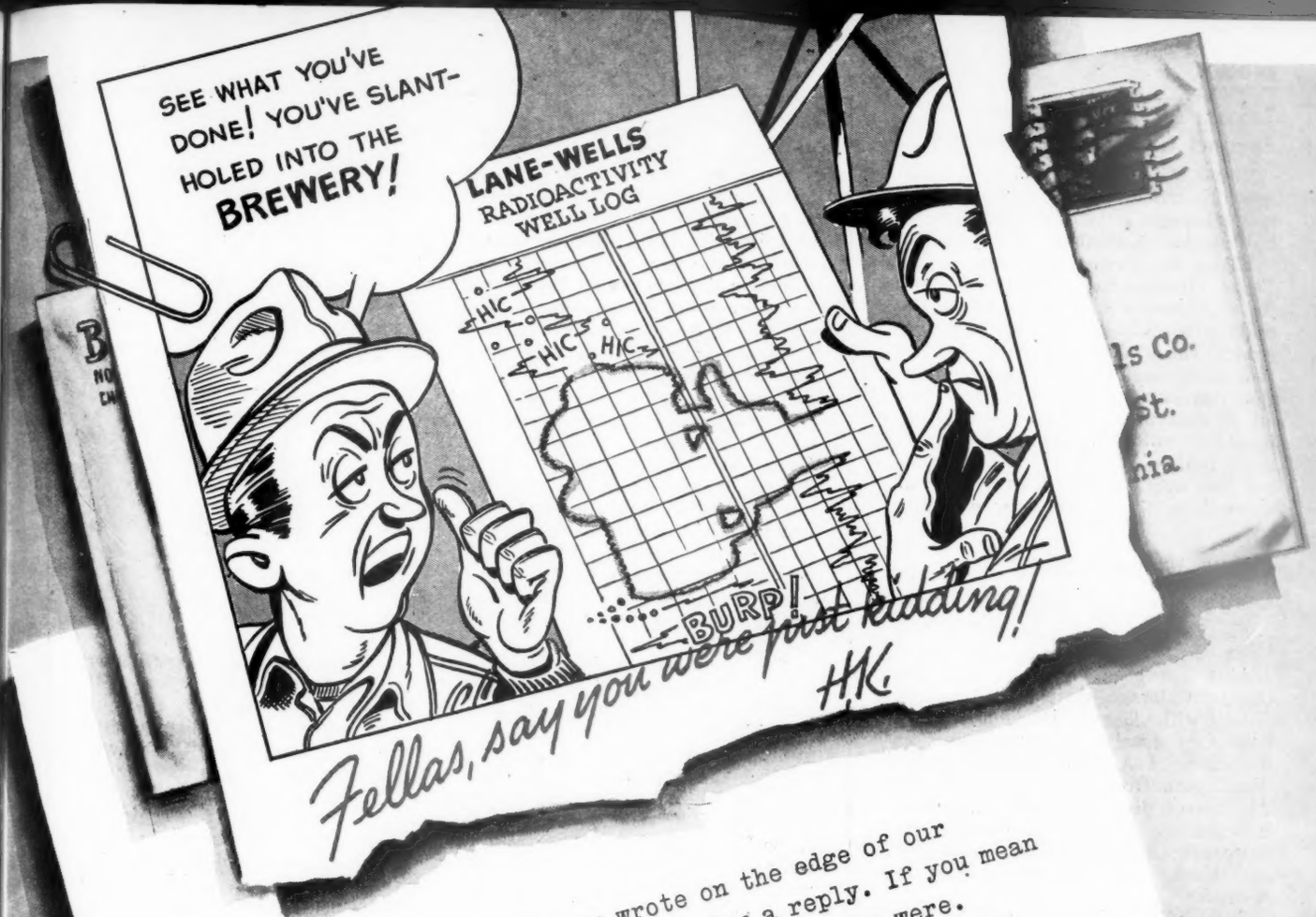


Dear Hank:

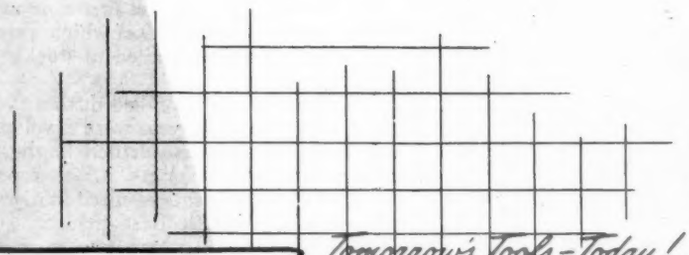
Received the note you wrote on the edge of our cartoon, and we're sort of stuck for a reply. If you mean were we kidding about the slant hole, sure we were. We've never known a driller careless enough (or maybe lucky enough) to do that.

But if you're talking about the behavior of the neutron curve -- well, yes and no. We've never claimed that the neutron curve would tell what kind of fluid, but it will indicate fluid in the formation -- and do that so accurately that, in some areas, we can tell you how much fluid. Quantitative interpretation is practically as remarkable as the cartoon, and plenty of operators can tell you how that's paid off for them.

Cordially,

F. R. Cordes

Lane-Wells Company



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Texas Oil Output Takes Second Cut in Two Months

Texas is producing 89,426-bbl of oil less this month than last month. The new allowable is 3,211,108 bbl, 176,000 bbl less than November's record high.

Bryan W. Payne, president of the Texas Independent Producers and Royalty Owners Association, hit oil imports in wires to six oil importing companies. The wire read in part: "For two consecutive months the Texas Commission has found it necessary to curtail oil production. Oil imports have continued an uninterrupted climb, exceeding a million barrels a day during the last four weeks of record, an increase of more than 30 per cent over one year ago."

Phillips' Utah District Combined with Denver

Phillips Petroleum Company's Salt Lake City, Utah, land and geological district has been combined with the Denver, Colorado, district to form one district with offices in Denver. The Salt Lake City district presently comprises the states of Arizona, Nevada, Idaho, Washington, Oregon, and parts of Utah; the Denver district includes Colorado, with the exception of the three southwestern counties, Wyoming, northeastern Utah, and the panhandle of Nebraska.

Charles W. Corbett, presently district landman at Denver, will be district landman for the combined districts, and Ardris Haig, presently district geologist at Denver, will be district geologist for the combined districts.

Orlo E. Childs, formerly district geologist at Salt Lake City, has been appointed director of a new exploration projects group formed within the exploration section of the land and geological department.

Superior, Butte Sign Deal

Superior Oil Company of California and Butte's Oil Fields, Inc., announce consummation of a drilling deal on acreage owned by both companies in equal interests in the vicinity of Corning, California. Twelve capped gas wells on the same area have proved production in shallow zones between 1500-1600 ft. Butte owns 10 of the wells. Superior owns the balance.

Under the terms of the deal Superior is to bear the entire cost and risk of drilling, which is to start within 60 days from signing of contract.

Group Buys Illinois Field

An investment syndicate headed by Bernhardt W. Klippel, Jr., has bought the Junction oil field in Gallatin County, Illinois. The field has 9 producing oil wells with total production of 45 bbl of oil a day. An engineering report by James A. Lewis Engineering, Inc., put the expected oil recovery from the present date on at 950,000 bbl. Operators expect to begin immediate water flood operations and will drill three or four injection wells in the first phase. The field was discovered in 1940.

DEEP WELL HYDRAFRAC*

In the past several years, producing formations have been encountered at greater depths, and as the number of wells drilled into these formations increase, the need for a process to stimulate the production from these well becomes more pronounced. The use of the Hydrafrac process in deep wells has increased as the number of deep wells increase and, at present, this service has been used with repeated success in wells as deep as 11,000 ft. Records of treatments performed in wells deeper than 11,000 ft are somewhat meager; however, the process was successfully used in a well in Oklahoma at a depth of 11,890 ft. One well in southwest Texas was treated at a depth of 12,378 ft, although the treatment was unsuccessful in increasing the well's productivity.

The Hydrafrac process generally involves injecting a viscous or low-filter-loss fluid (highly viscous oil or gelled hydrocarbons are preferable), usually containing a propping agent, such as sand, at a rate sufficiently rapid to build up the bottom-hole pressure until a fracture is created. In performing this operation in deep wells where high bottom-hole temperatures are encountered and lengthy placement times are required, the viscosity and fluid loss properties of the fracturing fluid must be considered in relation to the available pump rate. Both physical properties and necessary pump rate depend upon depth of the well being treated. The viscosity and fluid loss of gelled hydrocarbons are sensitive to the temperature; elevated temperatures tending to decrease both the time required for the gel to reach its maximum viscosity, and the time required for the fracturing fluid to "break back" or reduce in viscosity. Accordingly, in exceptionally deep or "hot" wells, special engineered gels are required. Special gels capable of treating a 20,000-ft well are being studied in the laboratory at this time and will be available for well treatment as soon as the demand for these gels exist. The pump rate is also a function of well depth as long strings of tubing increase the friction loss encountered while displacing the gels or viscous oils to bottom. Thus, Hydrafrac treatments in deep wells impose more difficult operating conditions on the pumps as this equipment is required to operate at very high pressure for long periods of time. In exceptionally deep wells (20,000 ft) it may be found advisable to use more or larger displacement pumps in order to place the fracturing fluid on bottom in as short a time as possible.

Other than having to "engineer" each Hydrafrac treatment in deep wells such that an optimum balance between injection rate and fracturing fluid viscosity (composition) is attained, no special problems are anticipated. On the basis of the data now available, no difficulty is expected in treating wells 20,000 ft deep, although the concentration of the propping agent may have to be increased to maintain the fracture open under the high stresses encountered at this depth.

*Stanolind Oil and Gas Company Report.

Gasoline Extraction Plants Scheduled by Sterling Oil

Construction of two gasoline extraction plants by Sterling Oil of Oklahoma, Inc., Tulsa, has been announced by Sterling's president, J. A. True. The first is to be situated in East Spring Valley field, Garfield County, north central Oklahoma. The other will be in East Edmond field, Oklahoma County.

East Spring Valley field, a Sterling discovery, produces gas with an unusually high fluid content from Mississippi lime at 5500 to 5800 ft. Other producing formations in the same field are oil bearing. The Mississippi lime reserve, being actively developed, has an estimated reserve of 175 billion cubic feet.

In East Edmond, also discovered by Sterling Oil, the Bartlesville sand is the producing formation. First wells in the development made only slight gas volumes but in the western trend, high gas/oil ratio wells were completed.

Saudi Arabian Crude Report

Crude oil production in Saudi Arabia during November amounted to 22,923,588 bbl, or an average of 764,120 bbl per calendar day, it was announced by the Arabian American Oil Company. This compares with 23,713,838 bbl produced in October, an average of 764,693 bbl per day.

Crude oil production for the first eleven months of 1952 amounted to 279,144,047 bbl, an average of 833,266 bbl per calendar day.

TPC Drills 32 Wells In First Nine Months of '52

The Tennessee Production Company drilled 32 wells in the first nine months of 1952, three-fourths of which were producers, a report mailed to stockholders showed.

Nineteen wells drilled during the first six months of the year were development wells, whereas five drilled in the third quarter were wildcats, it was reported. One of the wildcats resulted in discovery of the Hufsmith East field in Harris County, Texas, where two more wells have since been completed. Drilling to fully evaluate the new field is continuing.

The company is an affiliate of Tennessee Gas Transmission Company. Gardiner Symonds is board chairman and R. G. Rice is president.

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XUM

What's Doing in Drilling

Williston Basin Gets More Wells

North Dakota, an important area of the Williston Basin, now has 85 oil producers. Of this total Amerada Petroleum has 70.

C. H. Murphy, Jr., has brought in a 197-bbl producer, which is a 3-mile extension to the East Poplar field in Montana. The limestone pay was acidized with 500 gal. Perforated intervals are 5621-5629 ft and 5638-5646 ft, open hole exists from 5773 to 5783 ft.

Phillips Well Tests DI Zone in Canada

History was made when the Phillips Neilson well had a positive drillstem test some weeks ago. The test was carried out on the D1 zone, which is at 3465 ft and is about 20 miles east of the Camrose Armena field. The gravity of the oil was 34.6 and an estimated gas production was 550,000 cu ft per day. The oil recovery was 2800 ft.

Commercial production from the D1 has been slight in other areas in the past. Perhaps a great discovery has been made.

New Depth Record Set In West Texas Well

Gulf Oil Corporation 1 Mitchell Bros. State is drilling ahead at almost 15,900 ft. The well is 25 miles southeast of Marfa and is in east central Presidio County. Gulf abandoned at 15,468 ft their Thec Winfield well in Pecos County, which was their previous record.

Rotary Rigs Operating in Oil Fields of United States and Canada*

Weeks	Total	Gulf Coast	Pacific Coast	Illinois Oklahoma Kansas	Rocky Mountain Canada	West Texas New Mexico	Arkansas Texas Louisiana	North Texas
(November)								
Third	2863	609	169	658	427	519	141	337
Fourth	2902	630	168	672	413	521	154	344
(December)								
First	2799	640	170	619	403	505	146	316
Second	2962	625	179	715	418	516	146	363

*As reported to the American Association of Oilwell Drilling Contractors.

Spraberry Gets 80-Acre Spacing Approved

The controversial and unpredictable Spraberry came up into the news on the eve of Christmas. The Railroad Commission of Texas signed an order approving 80-acre spacing with an additional 80-acre tolerance. This would permit an operator to drill on a 160-acre basis if desired.

Commissioners W. J. Murray, Jr., and E. O. Thompson were in agreement with the new regulation, but Chairman Olin Culberson was in disagreement. Culberson was of the opinion that the policy of the commission should not assure and insure operators that drilling for an oil or gas well was a profitable venture.

The oilmen, however, were strongly requesting that the existing 40-acre spacing be increased as it is an unprofitable business. As an emphasis on the uneconomical aspect it was stated that today only 60 rigs were operating in the area, whereas two years ago there were almost 240 — a reduction of 300 per cent. The reduction was due to the profit motive, and not for the lack of development area.

The order is effective immediately. Changes in allowable will be as of March 1, in all probability. Quotas will be based on 25 per cent of the number of wells, and 75 per cent on spacing. Several hundred wells are, of course, on the old spacing, that is, 40 acres. The Commission will permit these wells to be produced as if on an 80-acre spacing. The 80-acre allowable is 121 bbl, and the 40-acre 76 bbl per day. The 160-acre will be 211 bbl daily.

Fifth Pay Zone Struck

Just north of the Acheson field in Alberta the St. Albert Unit No. 1 has tested oil from the D3 formation. The top of the pay is at 4645 ft and 59 bbl oil flowed in one hour.

Interests in the 850-acre block are Stanolind, Imperial, Pacific Petroleums, and Trans Empire Oils. The D3 is the fifth producing zone in the well.

Alberta's Bonnie Glen Field Is Extended

The southern edge of the Bonnie Glen field has been extended westward by a recent Texaco exploration well. Activity in the area is considerable. Texaco has five rigs, Standard Oil Company of California has two, and Hudson's Bay one.

Three-Zone Well Hit

In the Malmo field an initial potential of 680 bbl oil per day on an 18/64-in. choke was obtained from the Lower Cretaceous and D3 zones, in the Canadian Prairie. The D2 had previously been drillstem tested. The Lower Cretaceous and D3 will be dually completed and the D2 will have an offset well.

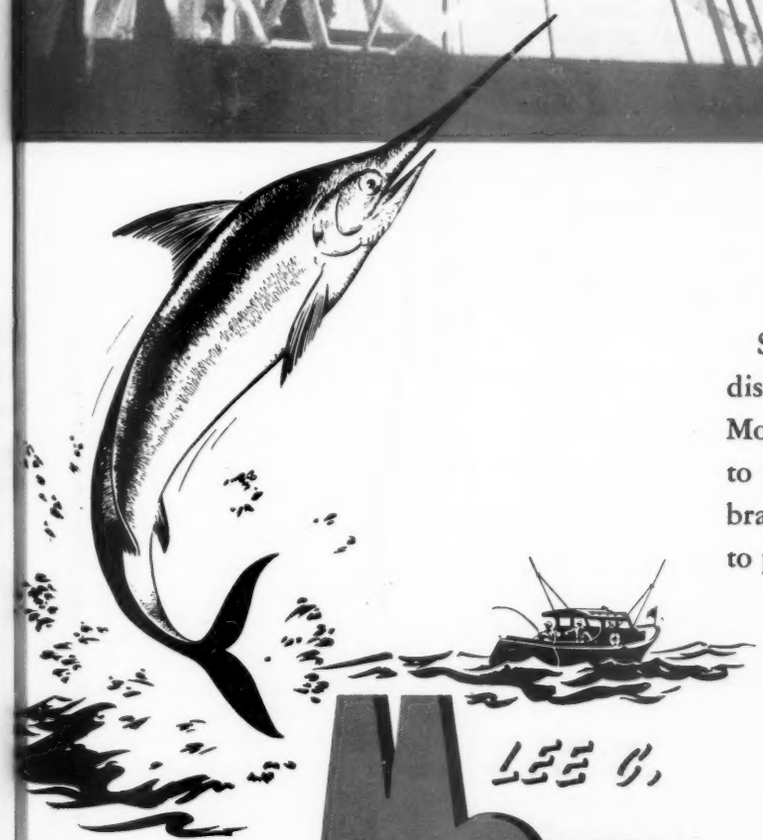
This triple pay producer is the Crest-Albermont-Leduc Consolidated Malmo No. 1. It is on a two-quarter farmout from Canadian Superior Oils of California.

Texas Drills 10,000 Wells

The state of Texas had over 10,000 oil well completions in 1952. In 1951, however, the total was 10,432.

The number of gas wells completed in 1952 will be about 740, as opposed to 861 for the previous year.

Ray Simmons, driller for Lauderdale and Straughan, drilling contractors, Abilene, Texas, at the brake of a West Texas wildcat near the town of Trent. The well is at 5515 ft, which is the probable completion depth.



Streamlining has made the Lee C. Moore Masts distinctive. More important, is the fact that the Moore streamline design makes the mast easier to transport, erect and use. There are no surplus braces or parts. Every piece has an important part to play in making these masts sturdy and efficient.

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Logging at Great Depths

In answer to a query about the use of the electric log at depths of 15,000 ft and below the Schlumberger Well Surveying Corporation replied that the basic electrical log —resistivity and SP curves—gives no problem at great depths. The company surveyed the Superior well drilled in Wyoming to 20,251 ft, the deepest well in the world, without incident. The cable used on this job was a standard cable and, because of its size, required more winch capacity than usual. As a result Schlumberger is currently studying long cables of smaller diameter capable of going 25,000 ft.

Certain auxiliary logging instruments, which contain electronic devices in the down-the-hole tool, may have difficulty at great depths. This is caused principally by the high temperatures prevailing at great depths.

Studies have been instigated with the object of correcting these tools for high temperatures.

Schlumberger is one of a number of service companies that are devoting research to the problems of drilling at great depths.

Oklahoma Has Deep Gas Well

An uncorrelated sand was discovered in the Cement field in Caddo County, Oklahoma. Deep South Oil Corporation located the sand in their Yule-Johnson No. 1 at a depth of 6616 ft. The well was formation tested from 6626 to 6690 ft with an initial production of approximately 35,000,000 cu ft per day. Some 185 ft of oil-distillate-cut mud was recovered. The flowing pressure was 750 psi with a closed-in pressure of 3460 psi. Deep South plans to drill 8 more wells in the area.

Sinclair Extension Well Drilled in Hulldale Field

Sinclair Oil and Gas Co. No. 1 Dwight McClatchey has extended the Hulldale field in north Schliecher County, West Texas. The initial flow test yielded 405 bbl 42 gravity oil in six hours on a ½-in. choke. The GOR was 420.

Production is from the Strawn sand with perforations from 5630 to 5640 ft.

Michigan Well Reworked

Miami Operating Company has completed the No. 1 Bonninghausen in the Cranberry Lake pool of Clare County, Michigan. The Miami company entered the area where the old pool had declined in output until it was carried in the abandoned list, and drilled to the Richfield formation at 5120 ft. Five-inch casing was cemented at 5010 ft and when plug was drilled out the lime was acidized with 3000 gal to flow 372 bbl in 24 hours.

The re-worked well is called a discovery for the Richfield zone, as other operators have found oil in the Traverse and Dundee limestones.

Wilcox Sand Extended

Jay Simmons is completing his No. 1 Jayne in the West Moore field in Cleveland County, Oklahoma. The well, which is extending Wilcox sand production, recovered water load in 4½ min and sprayed gas and water until shut in after 15 min. A core from 8760 to 8755 ft recovered 15 ft, of which the top 6 ft was sandy dolomite and the bottom 9 ft saturated Wilcox sand.

Gulf Hits Deep Production

Gulf Refining has hit deep production of high gravity oil in the Baxterville field, Lamar County, Mississippi. On initial test, the company's Andrews No. 25 flowed through a 3/16-in. choke at a calculated daily rate of 175 bbl of 40.6 gravity oil from 10,821 to 10,841 ft. Well is plugged back from 13,341 ft. Baxterville is Mississippi's biggest producing field, yielding about 17,500 bbl daily of 15 to 20 gravity oil.

New Zealand Has Production

New Plymouth Island off New Zealand is presently producing about 50 bbl high gravity oil a day. The operators are New Zealand Oil Refineries, Ltd., and Egmont Oil Wells, Ltd. Oil seepages were observed over a century ago on the mainland. New equipment is being brought in and the search for oil will be stepped up.

Oklahoma Pool Adds Well

Mercury Drilling and P. G. Lake have added a new well to the Northeast Prairie Valley pool of Garfield County, Oklahoma, with completion of the No. 1 Cogswell Heirs. The new well opens a new sand zone for the well, that of the Misener area.

New Hope Pool Extended

A new well recently completed by Magnolia Petroleum Company has extended the New Hope pool in McClain County, Oklahoma. It is the company's No. 1 Harris, which flowed 112 bbl of 44 gravity oil in 24 hr through ¼-in. choke. Gas-oil ratio was 500 to 1.

Alabama Well Flows 109-bbl

In the Pollard field, Escambia County, Alabama, Stanolind's No. 1 John Gray Unit well came in at 109 bbl per day on a 10/64-in. choke. BS&W 2 per cent. Gravity of the oil is 29 deg and the gas oil ratio 40:1.

The total depth is 6341 ft and 5½-in. casing was run to 6003 ft.

The well is completed open hole from 6003 to 6007 ft, which is in the top of the Massive sand. The Pilot sand is the chief producing zone in the Pollard field, but it was absent in this well.

Two New Oklahoma Wells

Sunray drilled Little Chief No. 1 to 2771 ft for Bartlesville sand production. The well is flowing 240 bbl oil per day.

Mid-Continent Petroleum Corporation Billy No. 1, Tulsa County, had the Arbuckle lime at 1897 ft. Casing was set at 1900 ft and drilling continued to 1917 ft. One hundred barrels oil flowed in two hours with 300,000 cu ft of gas.

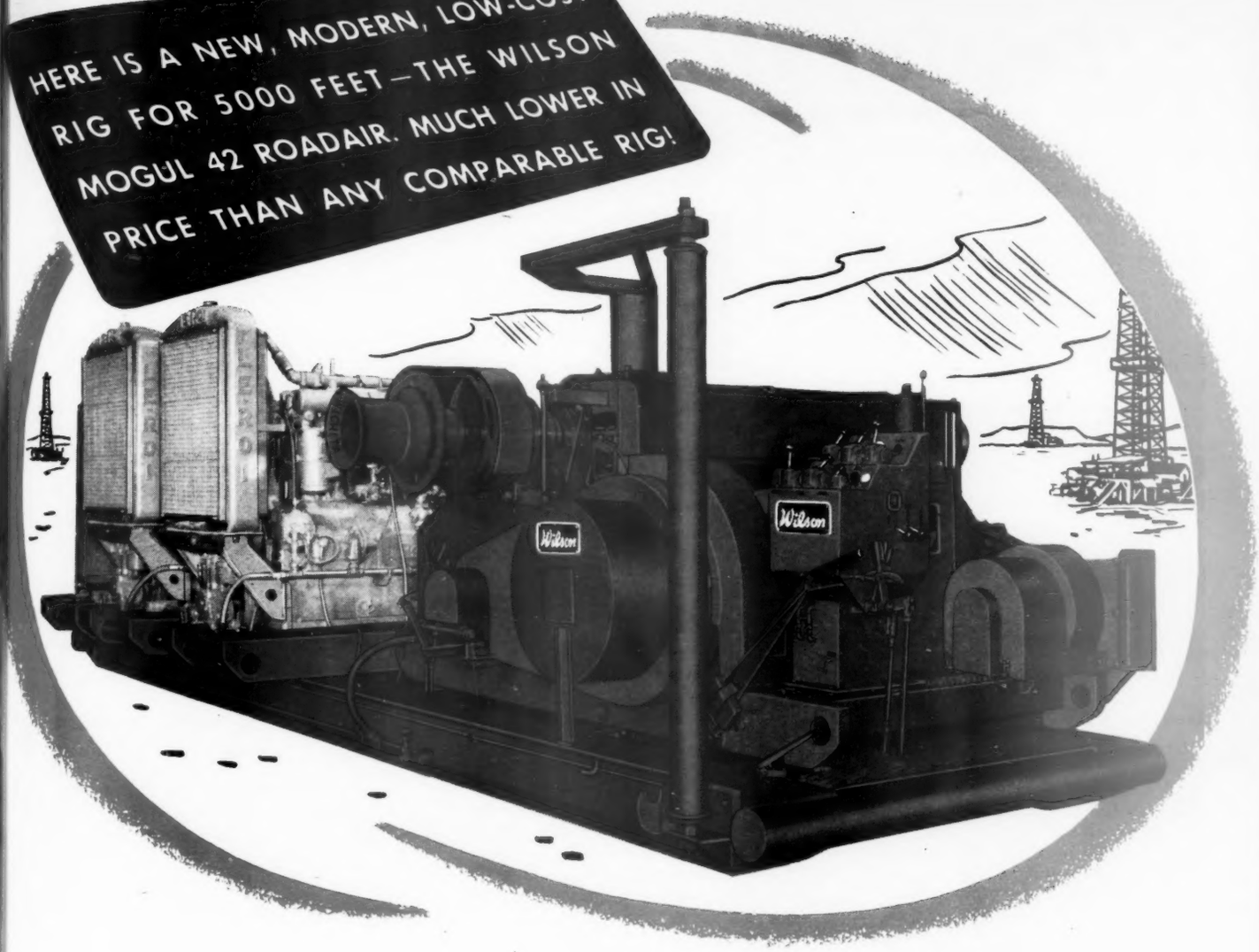
DESCRIPTIONS OF WELLS IN VENEZUELA DRILLED BELOW 15,000 FT*

TD, ft Prod. depth	Company Well	Drilled by	Field County or parish	Compl'd Spudded	Drill time, days	Casing and cementing schedule	Mud program	Bits, rock, drag and diamond	Cores Drillstem tests	Deepest form. Producing form., thickness	Perforations, production, pressures,* choke, GOR, gravity, etc.	Remarks
15,106 Dry	Caribbean Pet. No. 2-A Curacao	Venezuelan Oil Concessions	Cabimas Zulia	6-22-47 8- 3-45†	922	18⅝"/330'/400x-11¾"/4135'/1200x-9⅝"/4165'/400x-6⅝"/13,169'/500x.	Clay base to 6190' then oil emulsion		54 cores 1 DS	Eocene None	WC. Well was begun in 1931.	Deepest well outside U.S. at time of completion.
15,638 Dry	Colon Dev. Co. CT-1	Company	Catatumbo Zulia	11-27-49 8- 6- 48	471	20"/363'-13⅜"/1068'/1000x-9⅝"/10,060'/600x-6½" Lar./14,910'.	Clay base to TD. Oil emulsion testing		557' 1 DS		WC.	Deepest well outside U.S. at time of completion.
17,093	Creole No. 1 Alturitas		Zulia	50							WC.	Deepest well outside U.S.

WC — Wildcat. FW — Field well. Perf. — Perforations. IP — Initial production. C — Flowing casing pressure. T — Flowing tubing pressure. SC — Shutin casing pressure. ST — Shutin tubing pressure. x — Sacks cement.

*See page B-14-18 for table of wells below 15,000 ft in the United States.

HERE IS A NEW, MODERN, LOW-COST RIG FOR 5000 FEET—THE WILSON MOGUL 42 ROADAIR. MUCH LOWER IN PRICE THAN ANY COMPARABLE RIG!



"after all—the only thing we're talking about is MONEY"

The Mogul Roadair "42" Rig was designed to meet the need of those customers who want a rig *with compounded engines* of up to 400 H.P. total, to drill wells up to 5000 feet with 4½" pipe, without torque converters, and at the lowest total cost. This rig more completely fills all of these requirements than any rig we know. Of the 400 engine horsepower, 300 can be used on the pump and about 100 on the rotary table, and yet all 400 H.P. will be available when coming out of the hole.

The rig also has the safety and dependability inherent in having two engines, with compound, so that either can be used in the event of failure of the other. The V-belt compound is designed to use the high strength steel cord V-belts, which are run at fairly high speed, to carry relatively large H.P. in a narrow width.

It is equipped with a 118 Air-Tube disc engine clutch in a positively aligned clutch housing, which has proved so successful in other Wilson Roadair and Torcair Rigs.

The drum assembly in this rig is exactly like the regular Mogul Torcair "42" rig, which has two friction clutch drum speeds. But in addition it has a two speed jaw clutch transmission in a heavy plate case. The brake rings are "42" diameter, and brakes are 8" wide, full wrap type and cam and roller operated.

This is a fast, dependable rig, at the lowest possible cost, that will make possible *lower drilling costs than any other rig of comparable size!*

Compare Features... Quality... Prices

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WICHITA FALLS, TEXAS

*See page B-14-18 for table of wells below 15,000 ft in the United States.

953

XUM

Exploration Activities

Amerada Makes Fifth North Dakota Find

Amerada Petroleum Company made its fifth oil discovery in North Dakota recently. It is the company's No. 1 North Dakota "E", which flowed 124 bbl of oil and 71 bbl of water in 18 hr through 18/64-in. choke. The new well is halfway between Beaver Lodge field in Williams County and Charlson field in McKenzie County. Flowing from the Madison sand at 8674-9720 ft, gas flow was 162,000 cu ft on the test.

First Oil Hit Outside Nesson Anticline

The first well outside the Nesson Anticline in North Dakota has been completed by Crawford Smith and Zack Brooks Drilling Company in Bottineau County. The well, No. 1 Berentson, recovered 360 ft of fluid, 75 per cent oil, and 25 per cent oil-cut mud and water from 3245-3255 ft. Oil is 36 gravity.

Gusher Flow Hit in Kansas

Gusher production was hit in Kansas recently at the Smitherman and Cohen et al No. 1 Barney in Cohen County. While drilling in from the Bartlesville sand zone, with a total depth of 3343 ft, the well blew in, throwing tools out of the hole. It was shut in without damage, and estimated good for 2000 to 3000 bbl daily.

New Oil Field Opened In Montana Sector

Shell Oil Company has opened a new oil field in the Montana sector of the Williston Basin. It is the company's No. 21-33-B NPRR in McCone County. The well tested 1677 bbl of oil and 3 bbl of water and sediment a day. Oil tested 49.4 deg gravity. Open hole was acidized at 9185 to 9260 ft.

New Mexico Strike Made

Shell Oil Company has completed a new well in Lea County, New Mexico, its No. 1-C State. The well is a basal Wolfcamp lime discovery, one and a half miles northwest of the Lovington Abo field. It was completed for 504 bbl per day through 20/64-in. choke from 10,148-56 and 10,171-78 ft. Gas-oil ratio was 748 to 1.

South Dakota Oil Indicated

Oil has been discovered in South Dakota for the first time. About 9 miles east of the Wyoming border, E. P. Rothrock, state geologist, announced, a well drilled by Emil B. Kucera of Vermillion, South Dakota, recovered about a barrel of oil an hour from the Minnelusa sand. At 1376 ft, the well has been shut in. Strike is outside the limits of the Williston Basin, but the well is about 14 miles west of Mule Creek field in Wyoming.

Turks Invite U. S. Aid In Search for Oil

After 30 years of looking for oil itself, the Turkish government has announced that it will be happy to have American oil companies come in and develop its potential. George McGhee, United States ambassador to Turkey, and an experienced oil man himself, made the announcement, declaring that he believes there are great possibilities for oil in Turkey. Although the Turks have admitted that their government-sponsored oil industry cannot get the job done no laws have been passed yet that would be necessary before United States firms can be called in. The Turkish council, however, has announced its intention and will soon invite foreign specialists in world oil legislation to help prepare a law under which it can invite outsiders to participate in oil development in Turkey.

New Pool Hit on Canada Side of Williston Basin

Socony-Vacuum Exploration Company has completed a wildcat well in the Williston Basin to open a new oil pool. It is the Socony-Vacuum-Central Leduc-Del Rio No. 1 Ratcliff, five miles north of the Divide County, North Dakota, border in Saskatchewan. The well flowed 120 bbl of oil and 120 bbl of water daily from the Madison formation at 6349 to 6382 ft.

Magnolia Opens New Flow

Magnolia Petroleum Company has opened new production in St. Landry Parish, Louisiana. It is the company's No. 1 Armas Sylvester, which made an initial gage of 23 bbl of oil daily through a 9/64-in. choke plus a large volume of gas from 10,776-90 ft. Gas-oil ratio was 9300 to 1.

Large Louisiana Gas Well

Cities Service Oil Company has reported a large gas well in Terrebonne Parish, Louisiana. It is the company's No. 2 Delta Securities, which perforated the casing opposite four intervals to test the Krumbahr sand and tested for 107,000,000 ft of gas. Deepest testing was 12,630 ft.

Arizona Test Set

Western Oil Fields, Inc., of Denver, Colorado, has announced its plans for a 7000-ft wildcat test in Pinal County, Arizona, in the winter. Test will be southwest of Florence, Arizona.

Kentucky Well Completed

Hoffman-Basin-Reynolds have completed the No. 1 Igleheart in Hopkins County, Kentucky. Completion was made at 2459 ft to 2471 ft in the Paint Creek sand. Initial production gage was 33 bbl of oil a day on the pump. Wildcat is about 2½ miles from present production.

Cities Service Completes New Discovery Well

Completion of an oil discovery well in West Texas was announced by Cities Service Oil Company following a test of its Leverett B No. 1, located in Dawson County. The well flowed 143 bbl of 38.2 gravity oil in 24 hours through a ¼-in. choke from Spraberry sandstone. Local structural conditions indicate prospects of a higher ratio of recovery to oil in place than is usual in the Spraberry, operators said. The test well is producing from the Spraberry sandstone from 7690 to 7726 feet after having been plugged back from a total depth of 11,900 ft in the Ellenburger dolomite.

Texaco Drills Montana Well

The Texas Company has completed its No. 1 Northern Pacific north of Glendive County, Montana. The well was completed at 10,076 ft and showed a gage of 28 bbl of oil and 114 bbl of water per day.

Utah Well Nears Completion

Carter Oil Company's No. 1 Joseph Smith in Duchesne County, Utah, has been reported flowing 224 bbl of oil in 13 hr from the Green River formation at 9026 to 9032 ft. On a drillstem test from 8809 ft to 8857 ft, it filled with 3080 ft of 49-gravity oil in 2 hours.

Wyoming Well Flows From Mesa Verde Zone

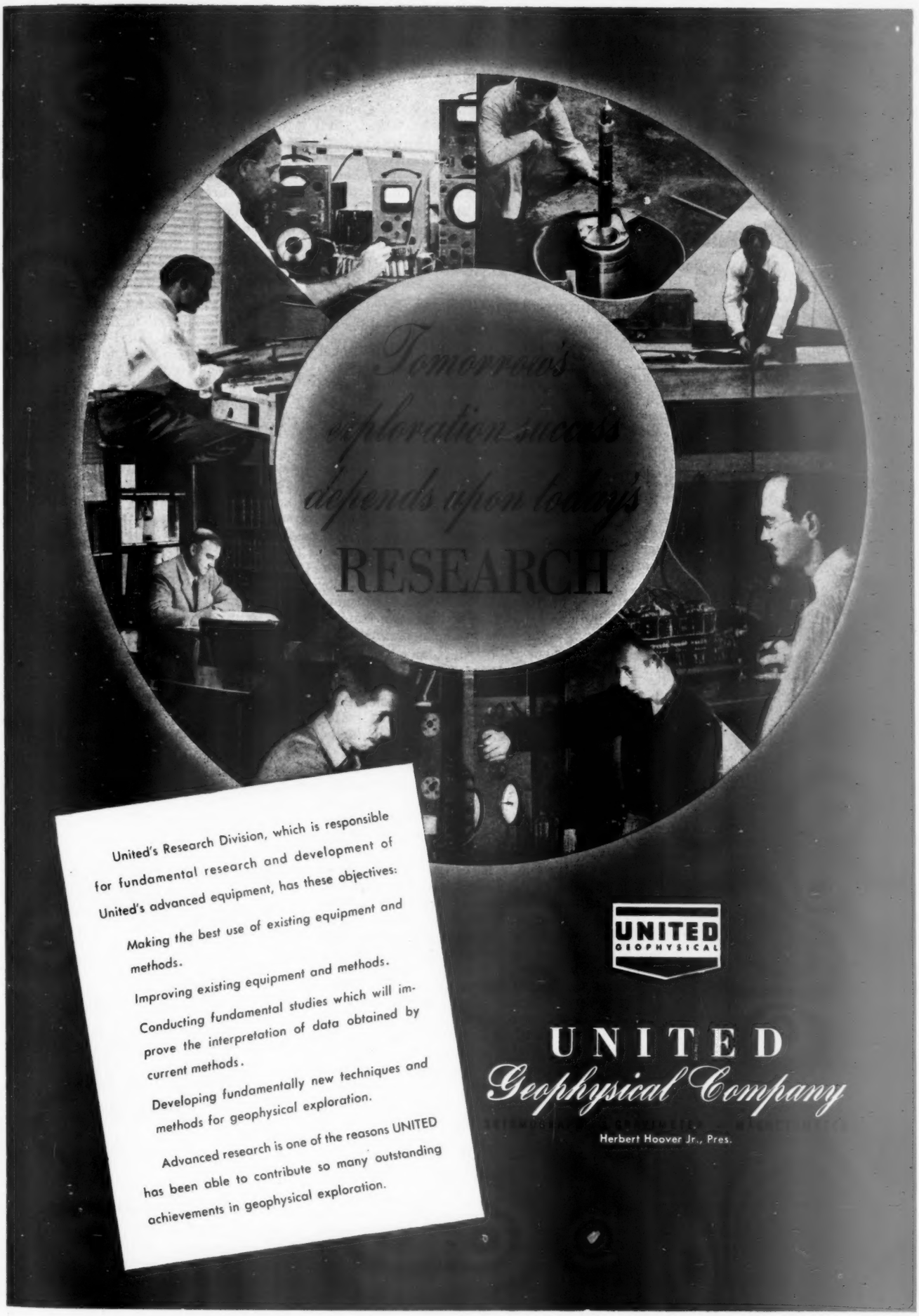
Stanolind Oil and Gas Company's No. 1 Unit in the Middle Mountain area of Sweetwater County, Wyoming has flowed at the rate of 169 bbl of oil per day. The well has been drilled to 8506 ft, and plugged back to 7800 ft for completion in the Mesa Verde sand. The well was held important because there has been little Mesa Verde sand production throughout the northern Rocky Mountain states, *Petroleum Information* reports.

New Gas Condensate Field

Union Sulphur and Oil Corporation recently opened a new gas-condensate field in Acadia Parish of South Louisiana. Discovery well is the Dewey M. Harmon No. 1, which flowed on official potential test at the rate of 53 bbl of 52.2 gravity condensate and 1,395,000 cu ft of gas daily, through a 12/64-in. choke. Test was made from casing perforations at 10,235 to 10,240 ft, with the well bottom at 11,208 ft. Tubing pressure was 3350 lb.

Louisiana Production Open

Humble Oil and Refining has opened production in Plaquemines Parish, Louisiana, with completion of its No. 2 State-Lease 1927. The new well flowed 76 bbl of oil daily through a ¼-in. choke from 8151-56 ft. Gas-oil ratio was 1775 to 1.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Exploration

Potash Deposit Seen

A large potash deposit has been found by Liberal Petroleums, Ltd., while drilling Liberal-Canada Southern-New Devon-Skyline No. 2 well. The company announced that with its associates it has acquired potash permits from the Saskatchewan government. Conventional coring methods revealed a thickness of 25 ft of relatively high grade potash about 3800 ft deep, the company reported.

Pakistan Field Indicated

A new oil field has been indicated at Chak Naurank near Chakwal in the Punjab, Pakistan, with the success of the first well drilled there by Pakistan Petroleum, Ltd. Following an acid treatment to open up the fissures of the productive limestone the well flowed about 200 bbl of crude oil in 24 hours. This crude contains a large proportion of asphalt and although it has not yet been possible to complete a proper analysis, it almost certainly contains only small quantities of light oils. It is too early to determine the value of the find.

Announcing this discovery, the prospecting company said that drilling of this well was begun in March this year and it was drilled to the oil-bearing limestone at about 7700 ft by the end of November.

West Texas Well Flows 2561 Bbl Oil Per Day

Amerada Petroleum Company has opened a new oil pool in Yoakum County, Texas, with completion of its No. 1 Weems, near the New Mexico line. The Devonian formation was hit between 11,773-860 ft and flowed 107 bbl of 43.4 gravity oil per hour through a ¾-in. choke for 21 hr, or at a rate of 2561 bbl a day. Flow was without acid treatment and gas-oil ratio was 178 to 1.

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New Sand Hit in Tobasco

Houston Oil Company and the American Republics Corporation are completing their No. 3 Temple W. West et al in the Tobasco field of Hidalgo County, Texas. The well has been given a potential for an estimated 14,000,000 cu ft of gas per day plus 71.22 bbl of distillate through perforations shot at 6934-44 ft. Production perforations are 730 ft below completion perforations shot in the 2 Temple W. West oil discovery where perforations were made at 6204-14 ft. Completion of the No. 3 Temple confirms new producing sand in the Tobasco field.

Sunray Land Offices Are Moved to Corpus Christi

The exploration and land department offices of Sunray Oil Corporation formerly in San Antonio, Texas, are being moved to Corpus Christi, Texas, this month, where the company has a district production office already established. The Sunray exploration, land, and production offices will be in new first floor quarters of the Wilson Tower Building in Corpus Christi, the production office moving into this space from present quarters in the Bevly Building.

E. V. Potter will be district landman in charge of Sunray's South and Southwest Texas land activity. W. M. Easley is to be district geologist. Both are moving to Corpus Christi from San Antonio along with some of the personnel from that office.

Sunray's Corpus Christi production district office is in charge of A. E. Hoffman, district production superintendent.

Sunray also has recently consolidated its former exploration activity conducted from Houston offices with the district office at Lake Charles, Louisiana, where new offices have been established at 1828 Rayon Street. Both Sunray's exploration and production district offices formerly in the Pioneer Building have moved into the new location.

Bert Timm is district geologist in charge of the Lake Charles exploration office, and Robert Mitchell is district land man. A. E. Hoffman is also superintendent and manager of this office for Sunray's production department.

The move of Sunray's Houston office to the Lake Charles, Louisiana, district, and of the company's San Antonio offices to the Corpus Christi district offices, is to effect a closer cooperation between the land, geological, and producing divisions of the organization, according to H. O. Harder, Sunray vice president and manager of the exploration department.

Shell Well Has Estimated Flow of 3648 Bbl a Day

Shell Oil Company has a large wildcat in Andrews County, West Texas. It is the No. 1-A-1 University, which flowed 51-gravity oil at a calculated rate of 3648 bbl daily on a 1-hour 45-minute drillstem test of the Ellenburger formation. Flow is through choke of unreported size at this time from perforations between 12,575 and 12,600 ft.

Louisiana Discovery Made

A gas-distillate discovery has been announced by Sunray Oil Corporation, which has completed its Simon LaLonde No. 1 wildcat, St. Landry Parish, Louisiana. The well, drilled to a total depth of 12,559 ft, was perforated 10,810-40 ft in a lower Cockfield sand and flowed at the rate of 5,600,000 cu ft of gas per day through 12/64-in. choke with 4300 lb pressure in the tubing. The drilling rig is being removed and an open flow potential will be taken.

Phillips Completes Large West Texas Producer

Phillips Petroleum Company has completed a large well in Andrews County, West Texas. The No. 1-CC Texas University was completed for a calculated daily flowing potential of 2310 bbl of 43.6-gravity oil through a ½-in. choke. Completion was made from perforations in casing opposite the Devonian lime at 12,490 to 12,556 ft, following treatment with 1000 gal of acid. Actual flow was 1155 bbl, showing a gas-oil ratio of 462 to 1.

New Kansas Oil Field

Pabco Drilling Company has reported completion of its No. 1 Casley in Kingman County, Kansas. This well opened a new field, Casley field, 1½ miles northeast of producing in the Lansdowne field. The well is producing from the Mississippi, and is rated at 318 bbl of oil daily by flow test.

Shell Well Success

Shell Oil Company has completed its No. 3 Kelly "B" in Beckham County, Oklahoma, for a flow of 498 bbl of condensate and 152 bbl water in 24 hr through a 22/64-in. choke. Gas-oil ratio was 6867 to 1. Production was through perforations from 9782 to 9795 ft and 9823 to 9897 ft. Total depth is 10,225 ft.

Deep Texas Field Open

A new deep field has been opened in Clay County, Texas, at Dillard and Waltermire Drilling's No. 1 George Segler. The well hit Ellenburger at 6298 ft and penetrated to 6312 ft. On initial test the well flowed 145 bbl of oil, with gas-oil ratio of 610-to-1, through an 11/64-in. choke in 17 hours.

New Wyoming Gas Well Seen

A new gas discovery is in the making in Sublette County, Wyoming, at Cosden Petroleum Company's No. 1 Miller. On a 2-hour drillstem test at 4430-59 ft, the wildcat flowed an estimated 5,000,000 ft, then increased to 9,000,000 ft of gas-cut mud.

Kentucky Discovery Seen

Slagter Producing Company has promises of a good well at its No. 1 F. P. Critser in Henderson County, Kentucky. The well recovered gas in 17 min, 910 ft of clean oil, and 120 ft of mud-cut oil in an hour drillstem test in the Benoist sand at 1999 to 2010 ft.

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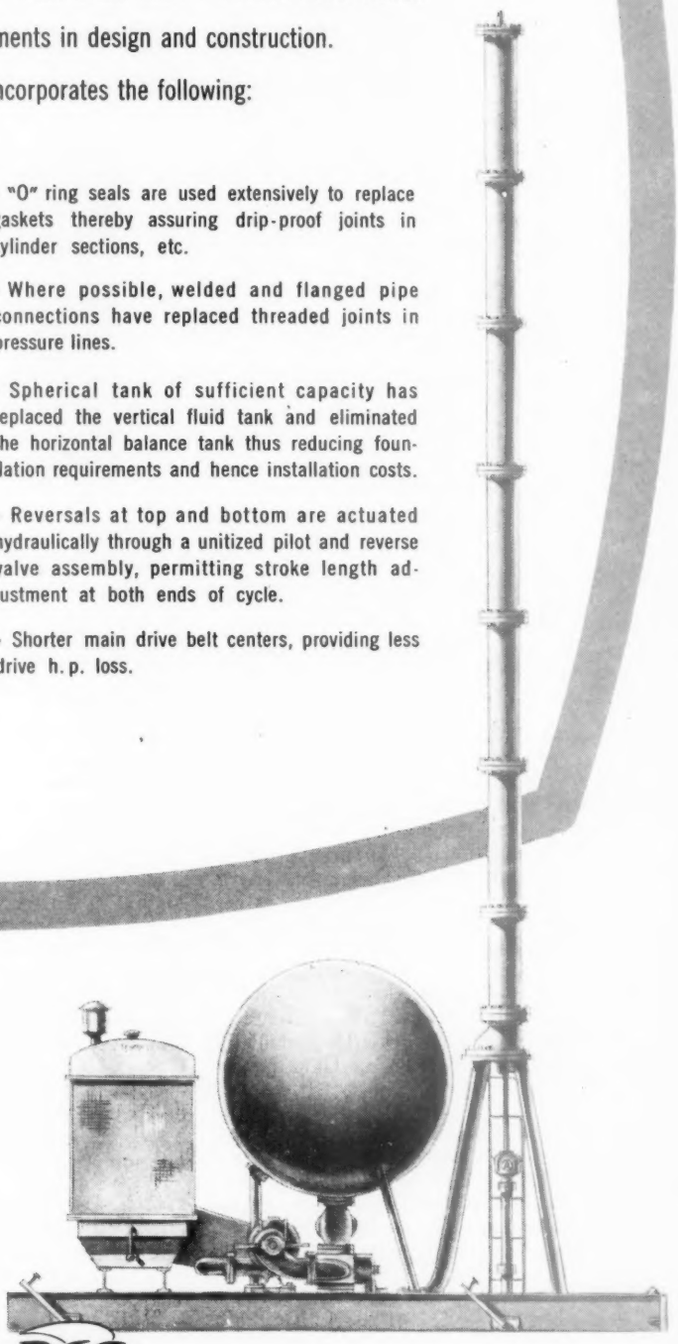

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XUM

Running Tour With Men in the Industry

Alexander Deussen, consulting geologist of Houston, Texas, and **Harry R. Johnson,** consulting geologist of Los Angeles, California, have been elected to honorary membership in the American Association of Petroleum Geologists.

Deussen is one of the "founding fathers" of AAPG, and served during 1918-19 as its second president. He began his long career in geology as an instructor at the University of Texas. In 1915 he joined Guffey Petroleum, forerunner of Gulf Oil, and opened his own consulting office in Houston in 1916. His consulting practice was interrupted only once from 1924-30 when he served as vice president in charge of the Gulf Coast operations of the Marland Oil Company.

Johnson, a Stanford University graduate, received his early training with the U. S. Geological Survey. Resigning from the Survey in 1910, he commenced an outstanding career as an independent consulting geologist that is now in its 43rd year.

Kenneth O. Austin of Wichita Falls, Texas, has been promoted to district engineer of Deep Rock Oil Corporation's Texas district. Austin was in the company's waterflood operations program in Garnett, Kansas, before being transferred to Texas in March of last year. A graduate of the University of Kansas, he joined Deep Rock in May 1951.

Earl M. Bagley has been named division geologist for Bishop Oil Company with headquarters in the Central Building, Midland, Texas. Bagley is being transferred to Midland from Bakersfield, California.

J. Eric Bucher has been named division geologist in Oklahoma for Magnolia Petroleum Corporation. His headquarters will be in Oklahoma City, where he was transferred last spring from Midland, Texas. He succeeds Dr. Walter L. Moreman, who recently transferred to the Dallas headquarters as a staff geologist. Bucher had been assistant to Moreman.

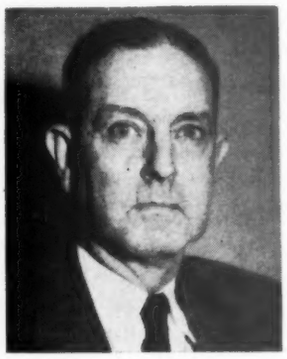
Fred S. Watson, Jr., has joined Gulf Oil Corporation at Casper, Wyoming, as a geologist. He was formerly geologist for Watson and Watson, of Okmulgee, Oklahoma.

C. M. Hartwell, who has just returned from service in the armed forces, has been named district superintendent for the oil production division of Cities Service Oil Company, at Hobbs, New Mexico, according to an announcement by J. A. Cleverly, manager of production.

Hartwell will have charge of the oil production properties formerly handled by **R. W. Ely.** Ely, who is assistant division superintendent, will act in the capacity of assistant to D. D. Bodie, division superintendent of all West Texas-New Mexico operations. He, too, will have headquarters at Hobbs.

J. W. W. (Mickey) Whitney, Jr., an engineer for Magnolia Petroleum Company, has been promoted to district engineer with headquarters at Wewoka, Oklahoma. Whitney is a graduate of the University of Tulsa, and is in charge of the Lisbon flood unit at El Dorado, Arkansas.

William C. Walker has joined Loffland Brothers Company as contract representative for the Permian Basin area of West Texas and New Mexico. Walker will make his headquarters in Midland, Texas. A graduate of the University of Kansas, Walker was formerly an engineer for J. P. Gibbins, Inc.



Morris A. Schellhardt

Morris A. Schellhardt, formerly chief petroleum engineer with El Paso Natural Gas Company, and for many years associated with the U. S. Bureau of Mines has joined the gas supply department of Transcontinental Gas Pipe Line Corporation—heading the production engineering department.

Schellhardt is well known to the industry for his many contributions to the study of gas well deliverabilities and production performance problems. He was associated for 18 years with the U. S. Bureau of Mines and the U. S. Geological Survey.

Transcontinental also announces the following additions to its geological department: **Edward W. Ely,** graduate of the Colorado School of Mines, was formerly associated with Pan American Production Company, and **Ralph L. Roberts,** a graduate of Southern Methodist University. The department is headed by **Lyle Austin,** a graduate of Texas A & M and the University of Houston.

C. E. Lee, general production superintendent in Shell Oil Company's Houston, Texas, area, recently observed his 35th year with that company. He was awarded a three-diamond tie clasp, the company's 35-year emblem, by E. D. Cumming, Shell vice president.

A veteran of Gulf Coast oil development, Lee worked on the first well Shell drilled in this area in 1924 in Calcasieu Parish, Louisiana. He came to Houston in 1929 and has been there ever since.

E. W. Masters, in addition to continuing his duties as area production manager for Shell Oil Company was named executive assistant to the vice president.

F. R. Schmieder was appointed general superintendent of Shell's western production operations. He will have headquarters in Los Angeles.

R. R. Robison succeeds Schmieder as San Joaquin division production manager in Bakersfield, and **J. E. Gallagher,** now superintendent in Bakersfield, replaces Robison as Coastal division superintendent at Ventura.

In the companv's Los Angeles Basin division, **P. E. Lehr** has been appointed division production manager at Long Beach. Other assignments within the Los Angeles Basin division include the appointments of **R. A. Malott,** formerly drilling foreman, to Brea district superintendent, and **D. K. Stewart,** formerly production foreman, to Long Beach district superintendent.

K. T. McCamman, production foreman at Bakersfield, has been transferred to the company's Coastal division as superintendent of the Ventura district.

Paul Bearden, Texas Gas Corporation engineer at the Winnie, Texas, office, has been appointed assistant to John T. Ashford, vice president in charge of production and gas engineering.

W. R. Thixton has been named division land manager for the central division for Sinclair Oil and Gas Company. Thixton, who has been with Sinclair for 18 years, will be in charge of activities in Oklahoma, Kansas, North and South Dakota, portions of North Texas, North Louisiana, and South Arkansas. He has been general land man in the Tulsa office for the last 10 years.

John N. Johnson has been named assistant to Thixton. A Sinclair employee for the last 25 years, Johnson has been general land man in the Tulsa office.

L. L. Aubert, president of the Bankline Oil Company, was elected president of the Western Oil and Gas Association for the year 1953, succeeding **R. L. Minckler,** president of General Petroleum Corporation, who had held the office for the past two years.

Charles S. Jones, president of Richfield Oil Corporation, was elected first vice president; **John W. Hancock,** executive vice president of Hancock Oil Company, was elected second vice president, and **William Reinhardt,** vice president of the Union Pacific Railroad Company, was elected treasurer. **John M. Pierce** (cq) was reelected vice president and general manager.

Twenty-nine incumbent members of the board were re-elected. Newly elected to the board were **F. W. Borden,** California district manager for Sunray Oil Corporation; **E. J. Hamner,** area manager for Humble Oil and Refining Company, and **T. H. Wallace,** vice president of Western Gulf Oil Company.

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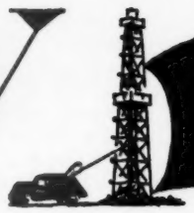

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SUMMARY, RESULTS IN THE FIELD, AND CONCLUSIONS

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Running Tour

R. F. Baker, vice president in charge of domestic production, The Texas Company, was elected an executive vice president of the company. Baker has been with the company since 1916. He was made a vice president in charge of domestic producing operations in 1949 and has been a director of the company since August 1950.

E. R. Filley, general manager of the domestic producing department, was elected a vice president of the company in charge of domestic production with headquarters at New York. Filley entered the service of the company in 1914 and was named general manager of the domestic producing department in 1949.

J. N. Troxell has been promoted to general manager of The Texas Company's producing department, succeeding Filley. Troxell, a petroleum engineering graduate of Pittsburgh University, has been assistant general manager of the producing department since January 1, 1950.

He joined Texaco as an instrument man in the Oklahoma division in 1922. He served as a geologist in that division and the South Texas division until he was transferred to the general manager's staff as a geologist at Houston in 1938.

L. T. Tighe, assistant division manager, has been promoted to division manager of South Texas division, producing department, Texaco. Tighe, whose headquarters will be in Houston, will succeed **W. C. Kneale,** who has elected to take early retirement.

The new division manager was graduated from Texas A. & M. College with a degree in electrical engineering. He was employed by The Texas Company, in 1919, and started to work as a rotary rig helper at Sour Lake, Texas.

Darrell Smith has been promoted to assistant division manager of South Texas division, producing department of The Texas Company, succeeding Tighe. Smith was graduated from Texas A. & M. College with the BS degree in petroleum engineering. His first job with The Texas Company was as rotary rig helper-roustabout at Hull, Texas, where he began in June, 1939.

D. L. Harlan, assistant chief petroleum engineer of Texaco's producing department, has been promoted to chief petroleum engineer. He is replacing **E. P. Hayes,** who will take over a new assignment.

Harlan was graduated from the University of Texas with the BS degree in petroleum engineering. His first job with The Texas Company was that of rotary rig helper at Port Neches, Texas, field in 1933.

Promotion of **J. A. Battle, Jr.,** to assistant chief petroleum engineer of Texaco's producing department, was announced by Filley. Battle, who is division petroleum engineer of Texaco's Louisiana division, will replace Harlan.

At the same time it was announced that **M. G. Trusdel,** assistant division petroleum engineer, will succeed Battle as division petroleum engineer, New Orleans, Louisiana.

The new assistant chief petroleum engineer was graduated from the University of Texas with the BS degree in petroleum engineering. He started with the company as a roustabout at Houma, Louisiana, in 1938.

Trusdel joined Texaco as a roustabout at New Iberia, Louisiana, in 1938 after graduation from the University of Texas with the BS degree in petroleum engineering.

L. A. Scholl, Jr., who had a 36-year career in domestic and foreign operations of The Texas Company, retired recently as geophysical consultant on the general manager's staff, The Texas Company, producing department. Scholl was graduated from Carnegie Institute of Technology with the BS degree in mining engineering. He also received the EM degree from the School of Mines, Columbia University, in 1916, and started that year with the old Producers Oil Company, a Texaco subsidiary, as a geologist.

Transfer of 14 employees from Signal Hill, California, laboratory to the research division of Texaco's producing department Bellaire, Texas, Laboratories was also announced. The Californians already are assuming their new duties with the company here, and their families will move to Houston soon.

The men transferred from Signal Hill are: **W. W. Robinson, Jr.,** assistant to director of research; **A. J. Belansky, Jr., V. N. Bednarski, David L. Cramer, Robert A. da Roza, George C. Ellis, Jr., Wilbur L. Hall, Theron Johns, James L. Maddox, Jr., Alfred C. Nestle, Victor J. Tronolone** and **W. J. Weiss,** all chemists; **Raymond J. Strawinski,** bacteriologist; and **Charles Forsey,** laboratory assistant.

S. A. Berthiaume has been promoted to assistant to general manager, The Texas Company's producing department, and has been transferred from Denver, Colorado, to Houston. Berthiaume was gradutaed from the University of Washington with the B.S. degree, studied at the University of California and received the Ph.D. degree from Cornell University. He started with The Texas Company as a geologist in June of 1940, working at Corpus Christi and Houston.

H. E. Christensen has been promoted to assistant division manager of the Rocky Mountain division, Denver, of Texaco. **F. D. Bode** will succeed him as division geologist, Rocky Mountain division, on the same date.

Christensen was graduated from the University of Colorado with the B.A. degree. His first job with The Texas Company was that of instrument man at Ardmore, Oklahoma, in the Oklahoma division, where he began in 1928. After working as a geologist at Tulsa and Wichita, Kansas, he was transferred to Rocky Mountain division in the same capacity in 1940. He was made division geologist of the Rocky Mountain division in 1943.

Bode received the Ph.D. degree at California Institute of Technology, and spent several years teaching at that institution and in foreign service for Standard Oil Company of California. He joined Texaco as a geologist at Los Angeles in 1942.

Neal Clayton

P. I. Bediz

Neal Clayton has been appointed assistant manager of the domestic field division, Century Geophysical Corporation, Tulsa, Oklahoma.

Clayton is a graduate of Mississippi College with a degree in physics and has a Master's degree in physics from Louisiana State University. He has had sixteen years' experience in seismic exploration, including two years in Venezuela and two years as associate physicist for the Naval Ordnance Laboratory.

Announcement also is made, of the promotion of **P. I. Bediz** to the position of chief geophysicist of Century for both their domestic and Canadian operations. Bediz attended the University of Istanbul. He later transferred to the Colorado School of Mines.

Joseph Neely, formerly district geologist with headquarters at Midland, Texas, has been promoted to a staff geologist and transferred to Magnolia Petroleum Company's general offices in Dallas, Texas.

W. L. Moreman, who has been Magnolia Petroleum Company's district geologist for the Oklahoma district with headquarters at Oklahoma City, has been made a staff geologist and transferred to Dallas.

F. E. Wimbish, formerly district geologist for Magnolia at Wichita, Kansas, has been transferred to Midland, Texas, as district geologist.

Owen H. Blexrud has been advanced to district geologist in charge of the Kansas district at Wichita.

David M. Muir has been promoted to party chief of a Magnolia seismic crew located at Dickinson, North Dakota.

George W. Isensee has been promoted to a seismic supervisor and transferred to Magnolia's general offices in Dallas.

O. H. Armstrong has been advanced to seismic supervisor and transferred to Bismarck, North Dakota.

Thomas B. Albright has been made party chief on a seismic crew with headquarters at Slidell, Louisiana.

Joseph B. Bellican has been promoted to a party chief of a seismic crew located at Port Arthur, Texas.

George S. Wilson, formerly district petroleum engineer at Magnolia's Alice producing district, has been transferred as assistant district production superintendent of the Vanderbilt district.

W. R. Walker, superintendent of the Vanderbilt shop, has succeeded **C. M. Reasor** as superintendent of the Alice machine shop.

Turner E. Thompson has been promoted to superintendent of Magnolia's Vanderbilt machine shop.

Recent Trends and Developments in the Natural Gasoline Industry*

JOHN F. LYNCH

THE manufacture of natural gasoline, by its very nature, has necessarily been copied and is an amalgamation of ideas from other petroleum and processing industries. There is, of course, a certain amount of originality in it, particularly in the ways and techniques of putting the various ideas together. Our technical people over the years have covered these various techniques ably and well. Even though we have done a lot as an industry, actually there is still a pressing need to produce more material more cheaply, and this is particularly true in the LP-Gas range with special emphasis on propane and ethane recovery. The lighter hydrocarbons, as you know, are the difficult ones to produce, store, and transport.

It is the author's opinion that there is a need for a new process. There have been many attempts to improve processing that have resulted in hypersorption, further refrigeration, better choice of absorption oil, etc. Those of you in technical fields are all familiar with these developments. There are opportunities for improvement of which I doubt that our industry has taken full advantage. Perhaps it has fallen into habits through practice and through tradition that are producing as good end results as should be had.

Contractor Engineers

I think, for one thing, we are not getting the best results from our contractor engineers. In my discussions with some of the contractors, these are some of the suggestions for improvement that were made:

1. More latitude to contractors on design.
2. Owner to share some responsibility on sizing of equipment in order that safety factors on sizing be reduced.
3. Owners to help in promoting the use of new ideas rather than making contractor stand full financial responsibility.
4. Active cooperation of owner's management to hold costs down.
5. Possible standardization of equilibrium constants within the industry.

During the last number of inflationary years, we have drifted away from the old practice of going to a contractor and saying, "Here is a certain quantity of gas of a specified richness. These are the utilities and materials available. Now give us the most economical plant you can on a turnkey basis."

In a good many instances, contractors are bidding turnkey today, but it isn't the turnkey of 15 years ago. A lot of us take it upon ourselves to tell the contractor every detail of what to do, and we want it done our way rather than charging him with the responsibility of building the most economical efficient plant possible. Unfortunately, we seem to have become entangled with a lot of organizational practice so that despite all of our efficiency of organization, we have considerable duplication.

One engineering contractor told me recently before he could get a change made in a plant he was building for a certain company, the print had to be approve by 12 different subsections, sections, or departments of the company.

It is fairly certain that effort is wasted along the line. Also, many an idea is stifled because the person who has it must do too great a selling job to ever get it across. I think some careful searching in many of our practices similar to this would uncover many such deficiencies.

*Presented at meeting of California Natural Gasoline Association, October, 1952.

The Author

John F. Lynch is president and a director of La Gloria Corporation in Corpus Christi, Texas. At present, as well as being president of La Gloria, Lynch is a director of Carthage Hydrocol, Inc., of New York. He is also president of Reynosa Pipe Line Company of Corpus Christi and vice president and director of Great Southern Chemical Corporation, also of Corpus Christi. Lynch attended Washington University in St. Louis, Missouri. He was first employed as a roustabout with Shamrock Oil and Gas Corporation of Amarillo. He was with Shamrock nine years, working in the production, natural gasoline, and refining departments before becoming assistant superintendent of operations. In 1939, Lynch left Shamrock to join the Fletcher Oil Company as refinery superintendent. He joined La Gloria Corporation in 1944 to take charge of gas cycling operations at the beginning of a program of expansion and new construction. He was made a vice president in 1946 and succeeded the late Robert T. Wilson as president early in 1947.

Use New Engineering

I also think we need to pay attention to a relatively new type of engineering that has become of great importance in the last 10 or 12 years — engineering physics. For the last 25 or 30 years the chemical engineer has played a very major role in petroleum processing. In recent years, engineering physics has taken on a great deal of practical importance. It seems that there is opportunity in our industry to do much with good utilization of engineering physics as our primary task is separation. Helium, for instance, may be separated from natural gas by diffusion techniques rather than by the refrigeration methods. Helium, in fact, is so light in comparison to other components of natural gas that its diffusion velocity, through a porous barrier, is over twice as much as the next lightest compound present in the same source. It may be even easier to isolate hydrogen by these new methods from a number of processed gases now used merely as fuel because its diffusion velocity is over four times that of any compound associated with it.

The direct isolation of natural gasoline fractions from crude petroleum without resorting to distillation and new types of fractionating columns has begun to appear feasible. I point this out only to bring to your attention the potentiality of such sciences and their application without in any way appraising their value.

Hand in hand with such developments goes the need for improved instrumentation; new heat exchange technique; improved pumping equipment, and improved analytical methods, such as the mass spectrometer.

All of this presents problems for the entire field of engineering, but especially engineering physics.

I would also like to make a few comments about the reserves, sales, and distribution side of the business. Most of you familiar with the natural gasoline business know that the largest part of its sales is generally in the area in which it is produced. In plotting a few figures, I found to my amazement that the states in the colder areas of our country use a very small amount of

natural gasoline, and further, the consumption of LP-Gas is almost phenomenally low in many of these states.

Now, I know, as most experienced industry people do, that transportation has been one of our big handicaps; but, also, I took a look at the gallons of domestic consumption of LP-Gas per capita in rural populations and found some amazing figures, part of which can be explained and part are difficult to explain. I did not try to find the answers, so I am only mentioning this in the event somebody might feel motivated to give it further thought.

Make More LP-Gas

I have taken the five main districts that have been established by PAW and PAD respectively and made some analyses of the consumption per capita of the rural population:

Massachusetts has 46 gal per capita
New York (not far away) has 21
Pennsylvania (in generally the same climate zone) has 11
Rhode Island—78
Vermont—24
Virginia—12
West Virginia—4

Moving to District Two:

Minnesota has 37 gal per capita
Michigan—19
Oklahoma (the high one) has 75
Tennessee (the low one) has 11
But almost as low in a very prosperous rural state: Ohio has 12

In District Three

New Mexico with 98
Texas—82
Louisiana—82
and on the other extreme:
Mississippi—31
Alabama—20

District Four has

Wyoming—107
Utah—slightly less than 10

And in District Five:

California has 46
Nevada—the same
Washington has only 10

These figures would indicate that there are many rural areas, which are potential consumers of LP-Gas. There are, no doubt, many of these areas in which the sales could be increased tremendously. Perhaps the greatest practical potential for new LP-Gas markets is in the 3,500,000 farm tractors now in use. It has been estimated that if 25 per cent of these farm tractors could be converted, it would increase LP-Gas consumption by a billion gallons per year over a present 4.1 billion gallons per year.

There are several factors which contribute toward making the present prospects of the LP-Gas industry appear bright. Some of these factors are: The large number of rural dwellings still using coal, coke, and wood for cooking fuel; the pronounced trend of population toward suburban and small town neighborhoods; and the new dwelling construction which is taking place beyond the gas mains.

The building of storage reservoirs is of great importance because in certain parts of the country during the winter months, the industry is out of balance by as much as eight to one. Such conditions as this create spot shortages unless storage can be provided to overcome them.

Actually, this storage can be provided and will be helpful at any points from the producer to the consumer. As my company is primarily a producing company, and is confronted with the problem of storage at the source of production, we have been fortunate in being able to solve this problem to a considerable extent by creating a storage reservoir in the producing formation.

I will describe this briefly. Our gas comes from one of the major anticlinal structures that has about 40 productive sands. The known sands range in depth from 5500 ft to 9000 ft. Often, the higher the sand on the structure, the smaller the reservoir, so we perforated the two top sands and dually completed a well in them. We put propane in one completion, and butane in the other. We take the propane or butane back through our plant separators and it so piped that we could put it through our fractionating system, but have found this usually unnecessary. We have recovered in excess of 85 per cent without reprocessing and now closely approach 100 per cent by reprocessing. This particular system happens to lend itself unusually well to our particular circumstances, but there are many similar conditions if they are searched out.

The National Committee for LP-Gas promotion is doing a great deal in its nationwide advertising and publicity campaign to correct many of the disadvantages of storage and handling.

The natural gasoline industry is becoming an increasingly important factor of the petroleum industry. If I were criticizing our industry, I would say that we haven't yet realized our potentiality or its importance. I say this because we have, to a considerable extent, grown up as an adjunct of the oil industry, and, at times, almost as a necessary evil—something had to be done with natural gas! We are now supplying such a large part of our entire fuel economy that we need to think and plan more intensively than we have in the past for full economy of production, transportation, and sales. No longer should the natural gas and gasoline industry be content with processing methods and techniques developed in other businesses. The possibilities for the use of lighter hydrocarbon components as single or mixed compounds are far too great to stand by while developments come from without.

Natural Gas Reserves

R. C. Alden, chairman of the Research Planning Board of Phillips Petroleum Company, Bartlesville, Oklahoma, in a paper entitled "The Availability of LPG for Direct Motor Fuel Use," brought to light some very important facts. He projected relationships of the discoveries, consumption and reserves of natural gas, natural gas liquids, and crude oils from 1930 to 1960. He found that on the discoveries we have been finding natural gas much faster than we have been finding crude oil, and to such an extent that if past trends continue to 1960, our cumulative discoveries of natural gas will constitute 55 per cent of total petroleum discovered. This compares with 1930 when the cumulative discoveries were only 30 per cent of the total.

The cumulative consumption of petroleum presents quite a contrast in that it demonstrates the relatively small use that has been made of natural gas. Even at the accelerating rate of natural gas usage, an extrapolation of the past trends indicates that our cumulative consumption of natural gas will only be 35 per cent of our total petroleum consumption in 1960. In 1930 it was 17 per cent.

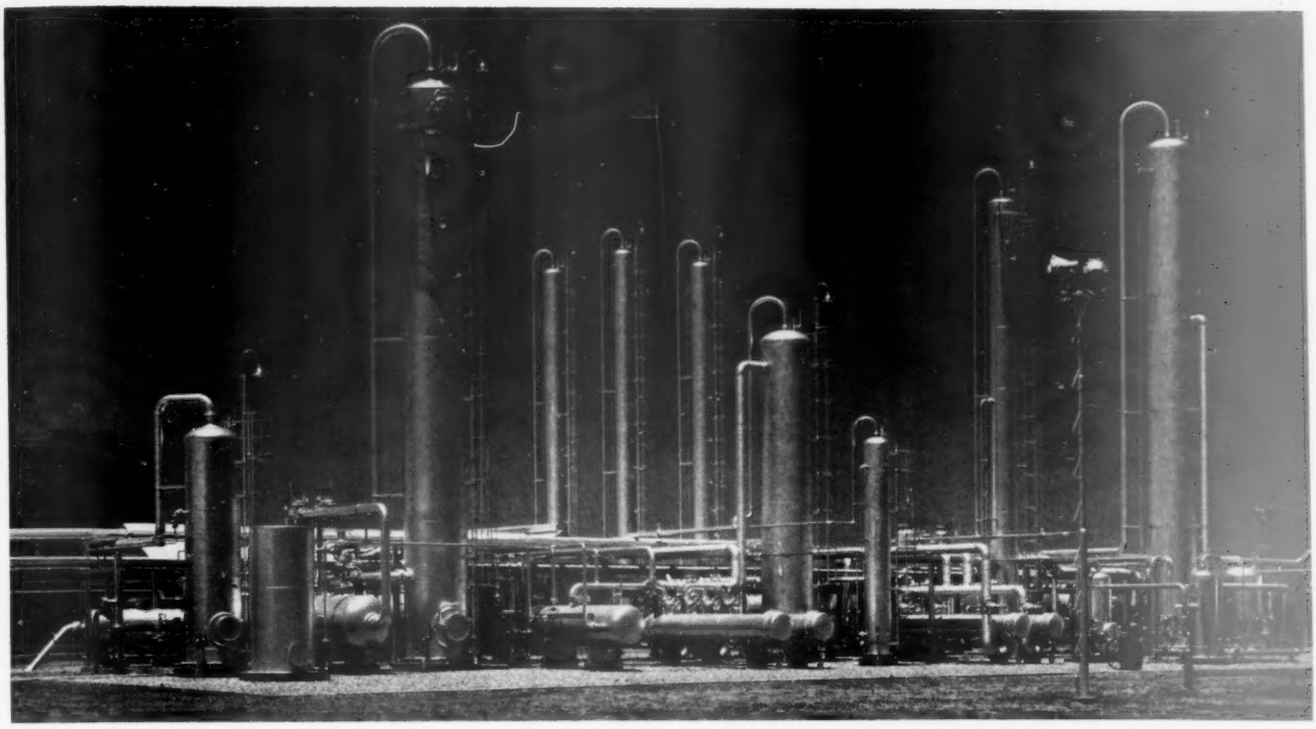
A study of reserves presents a startling contrast with the first two and is of greater significance because it portrays in part the road ahead. Extrapolating past trends to 1960, it is concluded that our natural gas reserves will be 72 per cent of the total petroleum. In 1930, they were 34 per cent. Projecting this trend in billions of barrels of reserves, it would appear that in 1960 we would have 42 billion barrels of crude as compared to 28 billion barrels today, and 112 billion barrels of natural gas and natural gas liquids in equivalent British thermal units basis as compared to 52 billion barrels today.

It seems of tremendous importance to utilize these sources of energy supply. The LP-Gas industry could play an extremely important part in the event of war. If gasoline were curtailed for domestic use as drastically as it was in World War II, and LP-Gas were established as an engine fuel, it would certainly release much additional gasoline to other uses. Also, it would be a splendid standby fuel if, for some unfortunate reason, heat and power facilities were destroyed. Also, it would be readily transportable as a fuel for cooking and heating, use in hospitals, in combat zones and isolated army camps, or for that matter, in any area where gas and electricity were not available.

If our industry could see fit to spend the amounts that some of our competitors do, such as our own gasoline marketing groups, not to mention the electric power industry, you would see the per capita consumptions that I have enumerated level off to a great extent, and the states only a few hundred miles apart would not vary so widely in consumption.

Conclusions

To summarize briefly, I feel the thing of greatest importance is to develop a new process that would markedly lower our cost and increase the quantity of production, create better application of company and contractor-engineer relationship, take a really close look at new engineering technique, particularly with respect to extraction and separation, and reappraise our distribution and sales efforts, particularly with the view of raising the present per capita consumption in so many areas where it is almost extremely low. ★ ★ ★



General processing equipment view.

Major Natural Gas Conservation Project

Two companies — Oklahoma Natural Gas and Warren Petroleum — cooperate to save gas in the Ringwood field, Major County, Oklahoma

BERT J. THOMPSON

THE Ringwood Natural Gasoline Plant serves the Ringwood oil field in Major County, Oklahoma. Contracts covering the construction and operation of the natural gas gathering, compressing and processing facilities were entered into early in 1951 as a joint venture by Oklahoma Natural Gas Company and Warren Petroleum Corporation. The latter corporation was chosen to supervise construction and to operate all gas gathering and processing facilities.

The project is another major step in conservation of natural resources in Oklahoma and the Southwest by the oil and gas industries. Various physical and economic circumstances dealt delaying blows to the proposals to build a natural gas processing plant in the Ringwood field since its early development dating back to 1945. Several proposed installations were diligently considered by progressive and conservation conscious oil and gas firms without development of a sound plan until the ultimate arrangement of a joint venture with Oklahoma Natural Gas Company and Warren Petroleum Corporation participating.

Gas Gathering

The gas gathering system required for this plant is quite extensive on a basis of tons of pipe required for each million feet of gas collected. Some of the smaller pipe is lapweld construction while the majority of the pipe from 6 in. size and larger is of the light gage spiral weld type. Pipe sizes range from 3 in. through 36 in. in diameter. A portion of the 36 in. diameter pipe crosses Indian Creek just west of the plant site. This pipe line suspension bridge is probably the largest line supported in this manner in the state of Oklahoma. Corrosion of the field pipe lines is being controlled in two ways; the first is by coating and wrapping all lines and second by the installation of magnesium anodes connected to the line at standard intervals. All lines have been insulated from existing separator and well installations by the use of insulating flanges. The gathering system feeds into the compressor and processing plant from two directions, the east and the west.

EXCLUSIVE

Compressor Installations

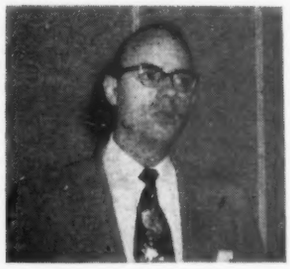
The main gas compression station is situated within the plant yard and consists of five gas engine driven compressors having a horsepower of 2500 each for a total installed compressor horsepower of 12,500. Gas is compressed from 0 lb gage to 760 lb through three stages of compression. It is difficult to convey the physical size of these gas engine compressors, however, some idea may be gained by the fact that each of the units assembled, complete with compressors, weighs 280.000 lb. Each gas engine unit has ten 19-in. stroke power cylinders and five compressor cylinders. Two 32-in. cylinders connected in parallel serve the first stage of compression, one 23-in. cylinder for second stage of compres-

sion and the remaining two 9¼-in. cylinders provide the third stage of compression. The compressed gas is cooled between stages with the conventional atmospheric type coolers located in the induced draft cooling tower.

One interesting feature about the original installation of this heavy machinery is that a temporary railroad spur was extended parallel to the compressor foundation blocks and each engine bed section, power cylinders, and crankshaft assembly, which with all extra equipment such as scavenging and compressor cylinders stripped off weighs 175,000 lb, was skidded directly from specially selected railroad flatcars to the foundation block making it unnecessary to handle this heavy equipment by truck. The first stage compressor cylinders are 32-in. bore and weigh approximately 8 tons each. A special heavy "A" frame and hoisting unit is required to handle these large cylinders because it was not feasible to install the entire building and craneway structures to handle these 8-ton units. A major mechanical design problem existed because of the great size of intake and discharge compressor volume bottles on either side of the compressor cylinders that required odd-angle nozzles and special foundation elevations. The largest of these bottles are 44 in. in diameter.

The 2500 hp gas engines are the angle type 19-in. stroke high compression machines. Each crankcase has a lube oil capacity in excess of 700 gal. Both lube oil and jacket water cooling is accomplished by aerial coolers.

The Author



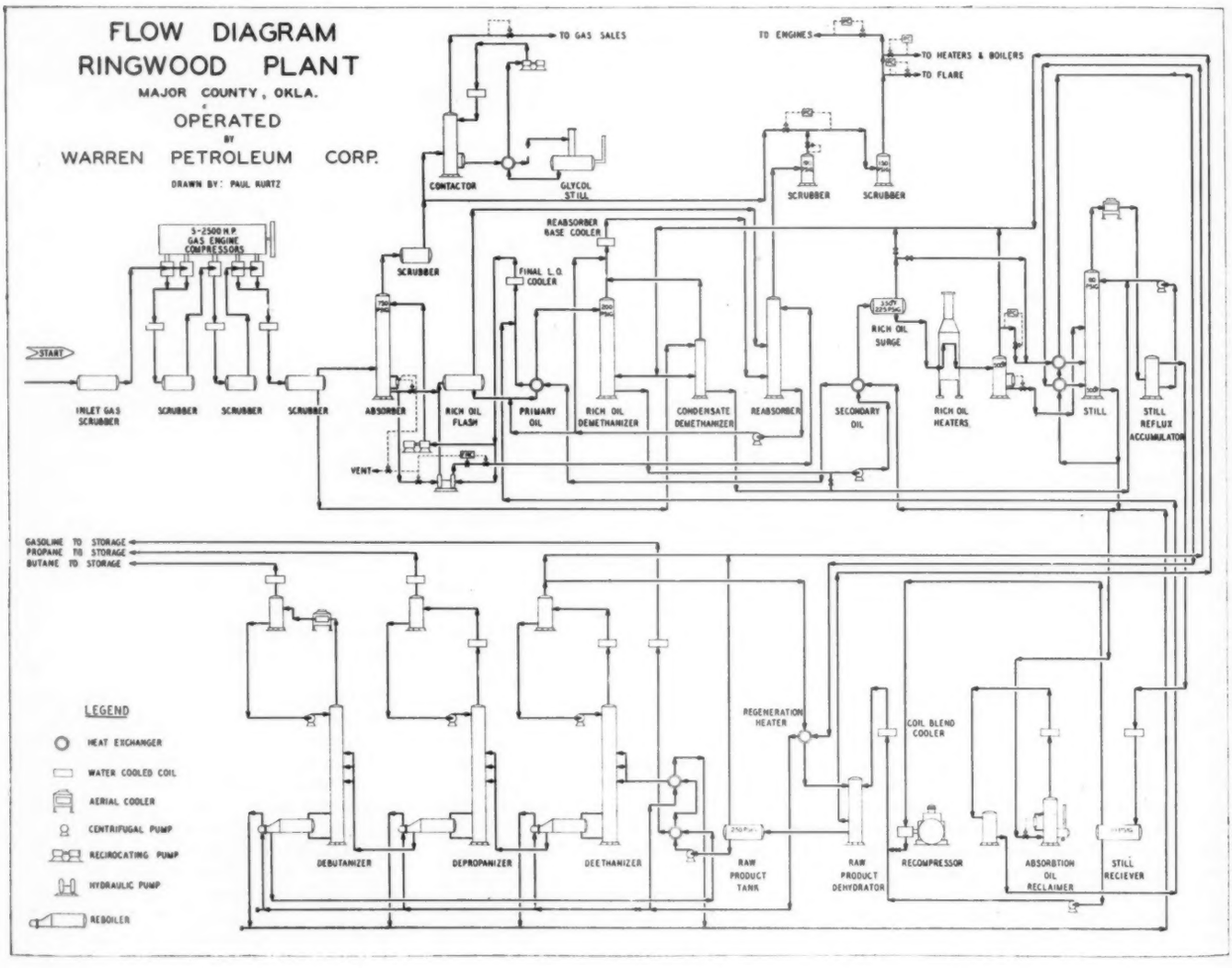
B. J. Thompson is a process engineer with Warren Petroleum Corporation, Tulsa, Oklahoma. He is a graduate of Oklahoma Institute of Technology, with a BS degree in chemical engineering, and has been formerly employed with Phillips Petroleum Company and Stanolind Oil and Gas Company. He is a registered professional engineer in Oklahoma.

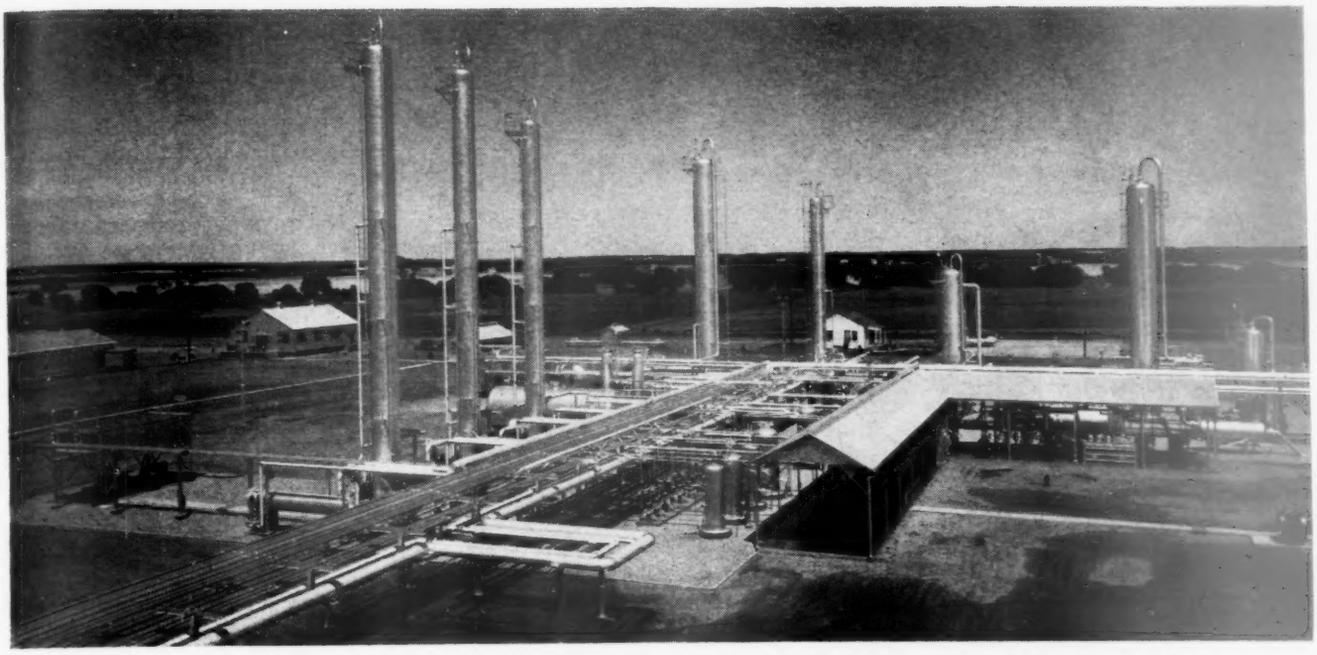
Absorption Unit

The absorption plant was designed to operate at 750 lb gage and to use a 210 molecular weight absorption oil. The absorber vessel is equipped with high capacity trays and does not require an intercooler when operating at design conditions to recover 60 per cent propane. The lean absorption oil leaving the still at 500 F begins its cooling cycle by providing heat to 90 F to reboilers, heat exchangers and is finally cooled in atmospheric coolers, thence is circulated to the 750 lb absorber by two plunger type quintuplex pumps. The quintuplex units normally run at 300 rpm but may be operated at 350 rpm. These pumps are powered by gas engines that also drive the recompressor for the recycled distillation unit vapors. Another feature of this unit is the power recovery from the rich oil flash step, which is described under "Special Features."

Rich Oil Stabilization

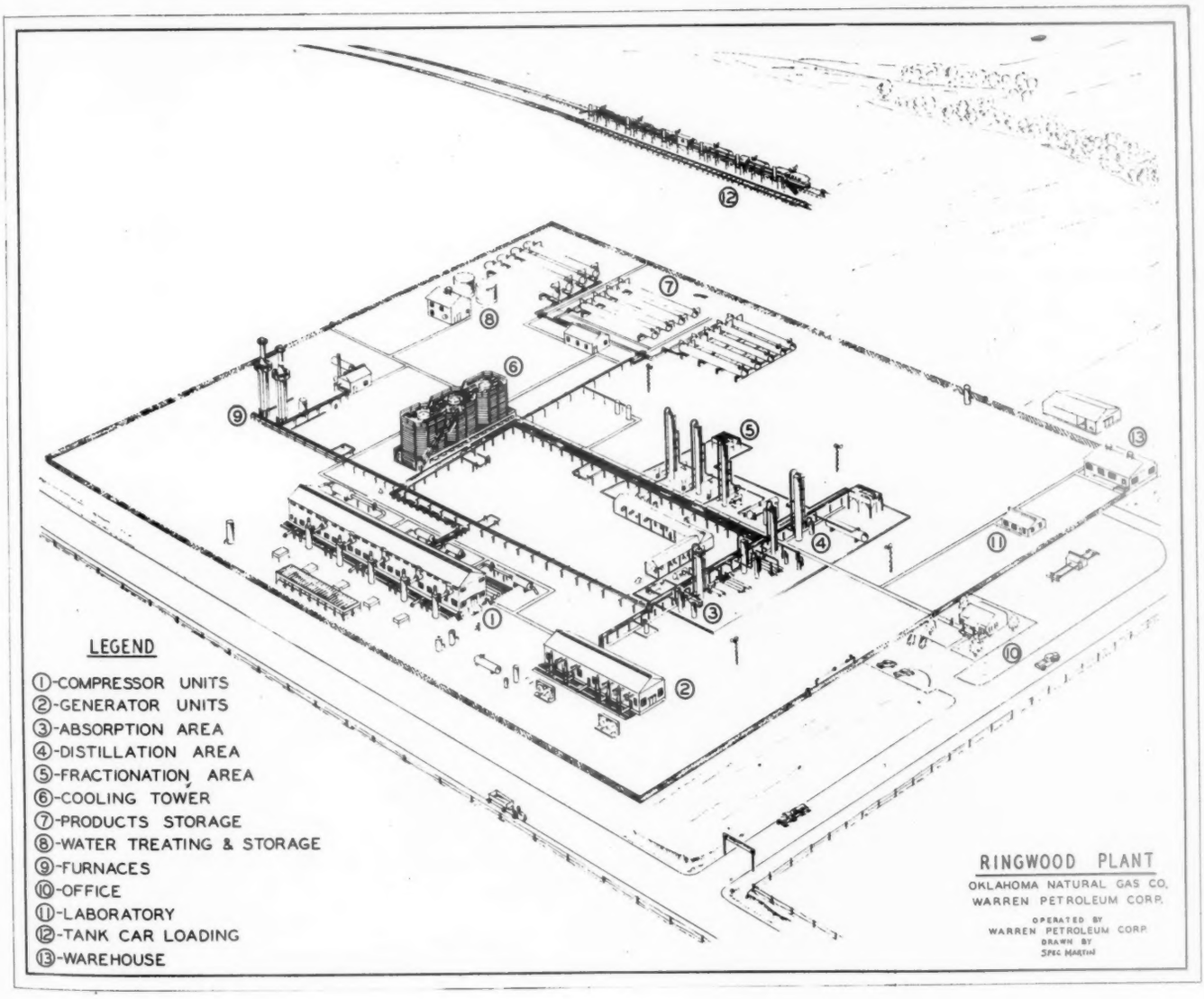
The rich oil flashed from the main absorber enters the primary oil exchangers and is heated to some 240 F and then is fed to the demethanizing units, near the top. The Ringwood plant is equipped with a rich oil stabilization unit consisting of two major units, the first being the stripping or demethanizing section and the second the rectification or reabsorbing section. A separate compressor condensate demethanizer operates in parallel with the rich oil demethanizing unit. The system includes

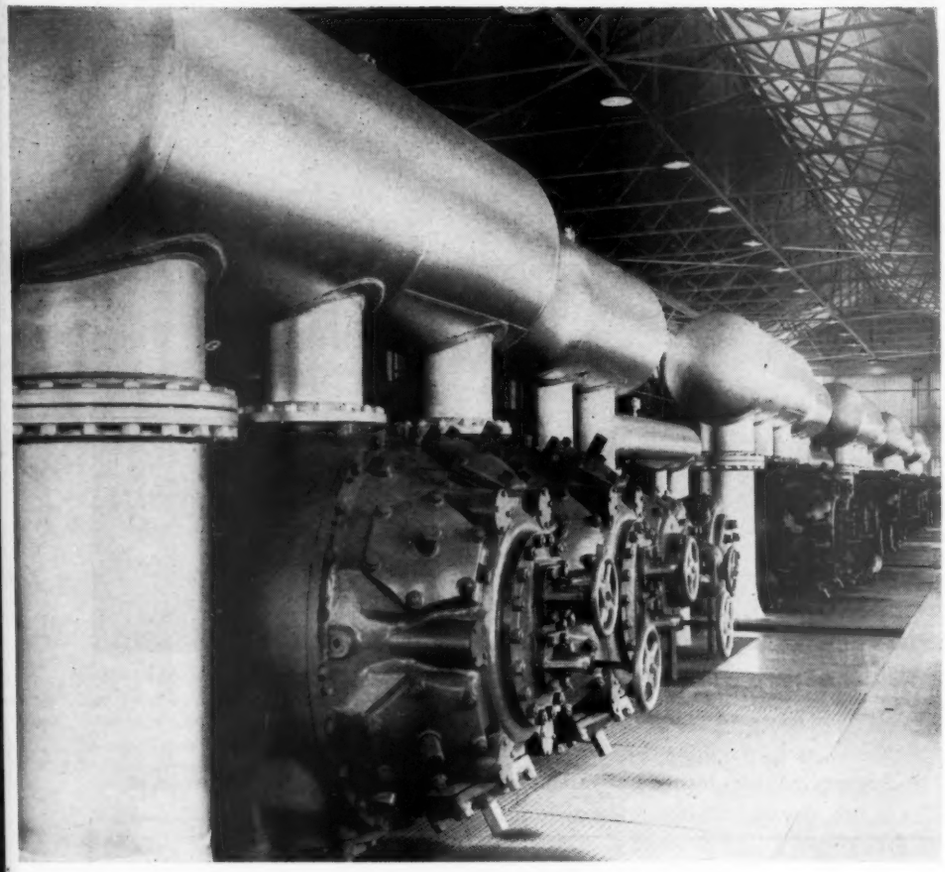




Process area at the Ringwood plant of Oklahoma Natural Gas and Warren Petroleum showing absorption unit at right, distillation in the center and fractionation at left.

A diagram indicates location of various units and equipment in the Ringwood plant.





Gas compressors, intake piping, and volume bottles.

an atmospheric cooler for the vapors going from the parallel stripping sections to the reabsorbing section. The demethanizing sections are provided agitation vapors from the deethanizer vent gas and/or the rich oil surge tank. Light hydrocarbon vapors stripped from the rich oil and condensate in the demethanizing sections are commingled with rich oil from the base of the reabsorbing section in an atmospheric cooler (base cooler). Commingling of these streams in the cooler provides a convenient means for removing a substantial portion of the heat of absorption normally present in a reabsorber and as a result much lower base or rich oil outlet temperature from the reabsorber is effected. The reabsorber is not equipped with any intermediate intercooler. Light vapors flashed from the rich oil, in a cold flash tank located between the main absorber and the primary exchangers, are fed to the reabsorber in the upper portion of the tower as the top 10 trays are adequate to reabsorb the desired propane. Feeding at this point in the tower helps to balance the tower load by decreasing the gas load at the base of the tower and distributing the absorption over several trays.

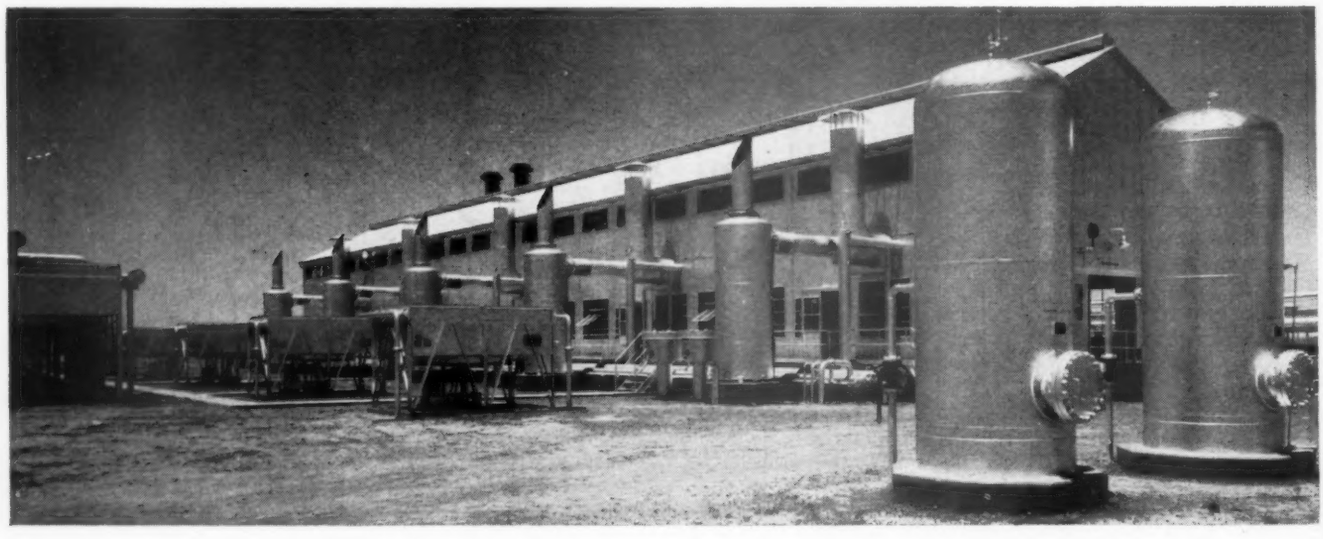
Distillation

The rich oil from the reabsorber is pumped back to the inlet of the primary exchangers to maintain the optimum heat balance. The rich oil from the base of the demethanizer is pumped through the secondary oil exchangers and the 350 F flash tank thence to direct fired furnaces where the oil is heated to 500 F or 525 F and then enters the lean oil still. It was necessary to install the demethanizer base pump to raise the rich oil surge tank pressure in order that vapors may be returned to the demethanizers for agitation.

The preheated rich oil may be fed to the still by either of two schemes (a) by maintaining a liquid level in a 510 F separator flash tank upstream from the still, a portion of the flash vapor can be fed into the tower below the main rich oil feed for use as primary stripping medium or (b) the total preheated rich oil may enter the still at one feed point without taking any pre-still flash. The piping arrangement is such that primary stripping or agitation vapors for the still may be provided from the hot flash tank (scheme (a) above) or the vapor stream connected from the 350 F rich oil surge tank. The molecular weight of either primary stripping stream is maintained at 44 or lower for optimum efficiency. The final stripping vapors are taken from the deethanizer vent system, which is a source of low molecular weight vapors.

The still is the combination type that has the stripping and rectification sections built into one tower. The still overhead gasoline vapor stream is condensed by an aerial cooler and is used for column reflux. By utilizing gasoline reflux instead of water and deethanizer vent gas for the final stripping, the distillation system is kept dry except for small quantities of water that enter the plant with the product stream, which initially came from inlet gas. The products made from the still overhead are

Service side of compressor plant including aerial coolers for lube oil and engine jacket water.



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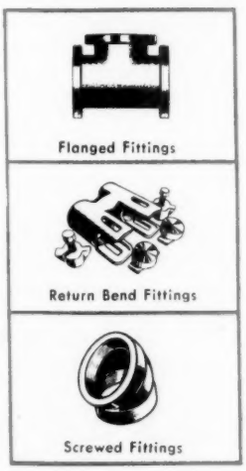

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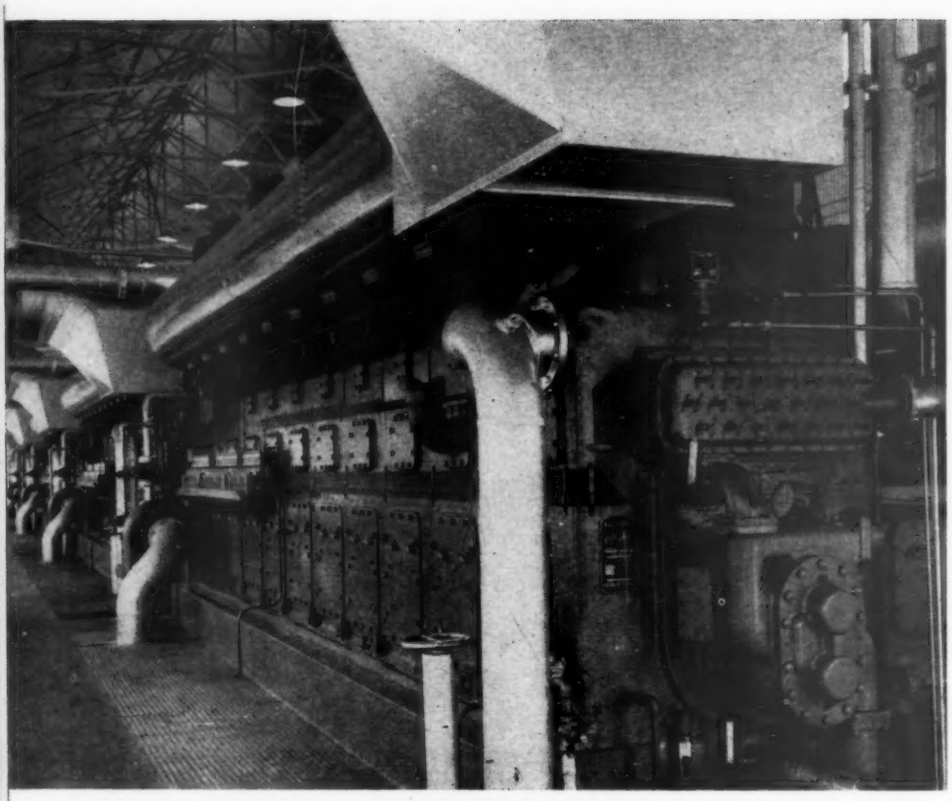


Power side of 2500-hp large angle gas engines.

delivered to the low pressure raw product tank operated at about 70 lb gage in which a liquid level is maintained. The vapors from this tank are recompressed and coil-blended with the pumped liquid from the same tank. The coil-blended and cooled stream is delivered to a mechanical water separator and thence to dry desiccant type dehydrator chambers from which point the product stream flows into the high pressure make tank operating at 200 to 250 lb gage as is required to totally condense the product. A charge pump takes the raw product from this tank through the conventional preheater into the deethanizer fractionator, which eliminates the ethane as an overhead vent stream. The deethanizer vent stream does not permit propane loss as the entire flow is utilized for agitation and must ultimately flow through the reabsorber before entering the fuel system.

Distillation and fractionation pumps at Ringwood plant.

Fractionation

The product fractionation plant consists of the conventional three fractionator towers, namely, deethanizer, depropanizer and debutanizer. After the ethane has been rejected overhead from the deethanizer, the deethanizer base product is fed direct to the depropanizer, which operates at 250 lb gage. The commercial propane product is produced overhead from the depropanizer, consisting of butanes and gasoline, is fed to the debutanizer, which produces a butane mixture as an overhead product and natural gasoline as a base product. Natural gasoline vapor pressure may be varied from a butane-free product to a 26 RVP product as required for natural gasoline sales. Heat to the reboilers for these fractionators is supplied by a portion of the lean oil stream leaving the still. All products are stored in conventional horizontal pressure storage tanks located within the plant yard.

Product Loading

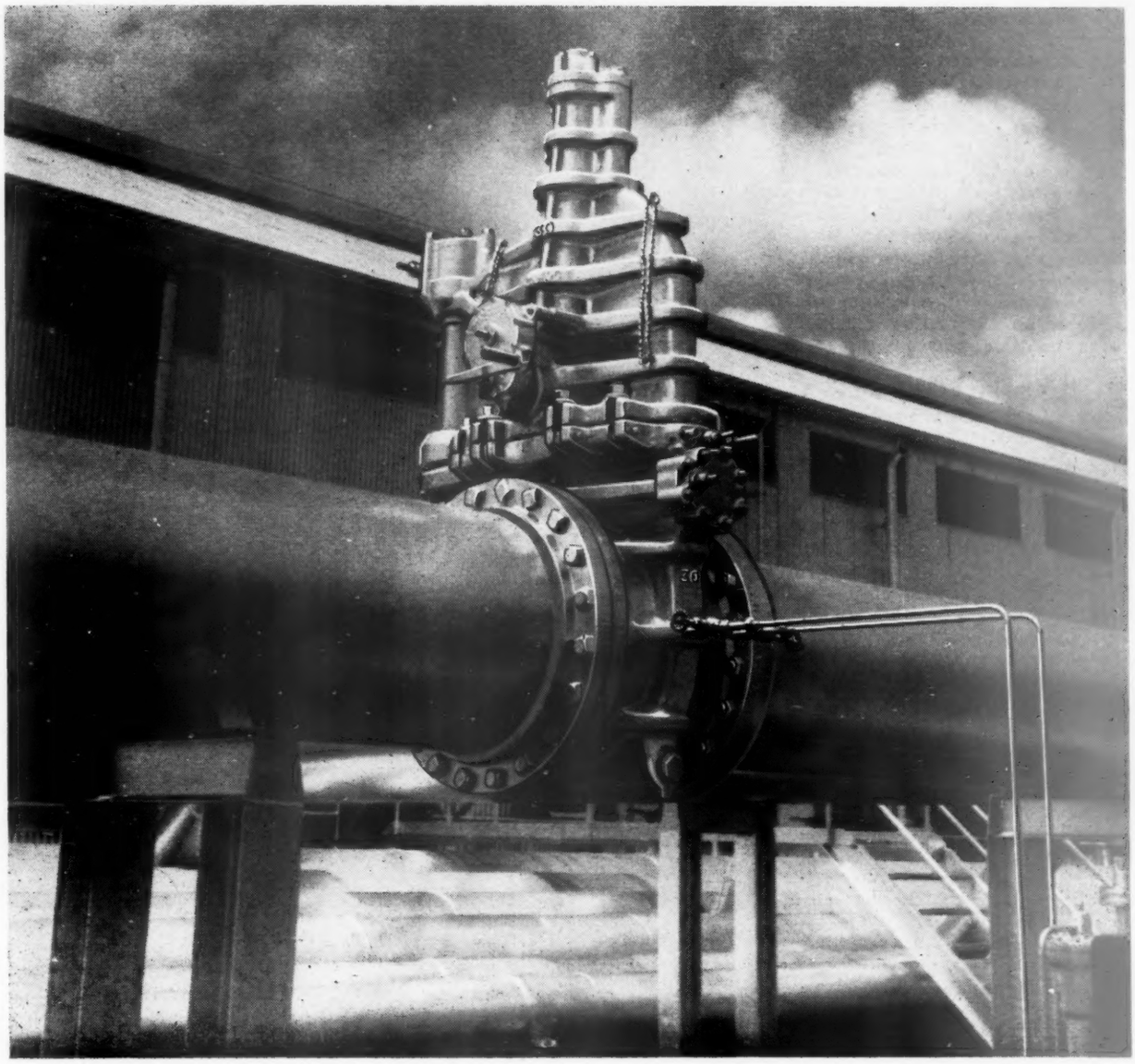
The tank car loading rack is situated just outside the plant fence, therefore, short loading lines are possible and it was not necessary to install expensive communication systems or loading control system to load products into tank cars. The truck loading dock for products is a greater distance from the storage and automatic pressure operated "on" and "off" switches have been installed on the loading pumps in order that the truck loader may begin or stop loading from the loading dock by opening or closing valves, thus eliminating the necessity for a second loader at the pump building.

Residue Gas Delivery

The residue gas from the primary absorption unit is delivered through a triethylene glycol liquid type dehydration unit thence through the meter station to the Oklahoma Natural Gas Company gas transmission system. The residue gas delivery line is equipped with an automatically controlled regulator to deliver any excess gas, above that receivable by the gas company line, to an emergency flare outside the plant yard.

Plant Equipment and Arrangement

The entire plant layout has been so arranged that operators find the cycle through the plant, while on an operating tour, enables one operator to observe all major operating equipment as he passes in the continuous path through the plant. For instance, he may begin at the compressor building, proceed through the oil pump-recompressor units and generator building, thence to the absorption unit, distillation unit, product dehydration, fractionation, cooling tower, products storage, water treating, direct fired heaters, and thence back to the compressor building. The control building and process pumps are located adjacent to the absorption, distillation



This 30" Commercial Type CS Orifice Fitting is installed at Warren Petroleum Corporation's New Ringwood Natural Gasoline Plant in the Ringwood field, Major County, Oklahoma. 24" Type CS Orifice Fittings are also included in this installation.

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and fractionation units which are arranged in an "L" shape shown in Fig. 4 with the still being at the base of the "L." The entire plant layout allows for future expansion of major units including compressors, absorber, fractionators, cooling tower, and storage.

Aerial cooling for high temperature level cooling has been used extensively to conserve water, which is a costly utility. Aerial coolers have been used for cooling jacket water and lube oil for all gas engines in the plant, for a reflux condenser or primary cooler, for the still overhead product and for a similar service on the debutanizer.

Hydraulic Drive

One of the newest and most unique equipment installation in this plant is the use of a combination hydraulic drive and pumping unit. The power end of this hydraulic unit receives 750 lb rich oil from the main absorber and takes the pressure drop to the initial rich oil flash tank operating at approximately 250 lb gage. This pressure drop supplies sufficient power to drive a similar hydraulic unit that is pumping lean absorption oil to the reabsorber. The excess rich oil, above the hydraulic unit requirement, flows direct to the flash tank as regulated by the absorber level control. An automatic control will stop the combination hydraulic unit in the event the level in the main absorber should be lost. This arrangement prevents release of high pressure gas from the base of the absorber into low pressure distillation equipment. This type power, utilizing horsepower normally not recovered in the plants, offers extensive possibilities for other similar horsepower requirements.

The use of pneumatic control transmitter units, for both temperature and flow control services, have been used extensively in this plant. These pneumatic transmitter units make it unnecessary to pipe, through instrument tubing, gas, or product streams direct to the control room thus removing part of the operational hazards within many control rooms. These remotely situated transmitter units make the control unit and system very sensitive and responsive to operating changes.

Another feature is the employing of light hydrocarbon vapors from the flash tanks for primary stripping and the deethanizer vent vapors for final stripping in the still. Use of raw product reflux to the still and hydrocarbon vapors for stripping make the still unit a relatively dry operation. Some of the advantages of operating a dry still are (a) the elimination of a large steam plant, (b) the dry system substantially reduces equipment corrosion, (c) equipment freezeups will be reduced materially, (d) in plants that dehydrate the gas before it enters the absorber, propane or product dehydration may be eliminated and (e) the dry (hydrocarbon) stripping provides sufficiently dry absorption oil to lower the dew point of the gas passing through the absorber by some 15 F thus making feasible the use of glycol dehydration for the residue gas.

The reabsorber unit residue gas is satisfactorily lean to be used for engine and furnace fuel, therefore, the majority of the plant fuel is supplied by residue gas from the reabsorber unit. The makeup fuel supply regulated with a pressure controller is supplied from the high pressure residue gas system. The arrangement of using low pressure gas for fuel provides maximum utilization of compressor horsepower for delivering high pressure residue gas to the Oklahoma Natural Gas Company system.

Gas dehydration, absorption and rich oil distillation towers and piping in the Ringwood plant.

Contractors

Gasoline Plant Construction Corporation of Houston, Texas, was the engineering and construction contractor for all plant facilities. Warren Petroleum Corporation engineers collaborated with the plant contractor in the design and installation of the facilities. Tulsa Pipe Coating, Inc., cleaned, coated, and wrapped all field gas gathering pipe. Pipeline Service Company of Seminole, Oklahoma, was the pipe line laying contractor. ★ ★ ★

Petrolite Announces New Distillate Treating Process

The Petreco Division of the Petrolite Corporation announces an electric process for treating distillate stocks with acid, alkali, doctor or similar chemicals.

The new process provides continuous, automatically-controlled treating with predictable results. One of the interesting features of the process is the comparatively small amount of equipment and ground space required, the treater usually not being larger than 10 ft in diameter. Another feature is that additional equipment such as pumps, tanks, filters, centrifuges, etc., is, in many cases, virtually eliminated.

The process is applicable to distillate stocks such as naphtha, gasoline, kerosine, cat-cracker charges, cat-cycle oils, diesel fuel, and furnace oil. It is entirely closed; electric power requirements are within the normal capacity of the usual refinery power supply.

Automatic devices control the entire treating operation with precision. This action of the electric treater is fast, assuring a quick break and complete separation. In acid treating, the amount of acid sludge formed is reduced, and the sludge formed is suitable for re-use or recovery. In caustic treating, emulsion in the caustic effluent is eliminated; in doctor treating, no black-strap is formed.

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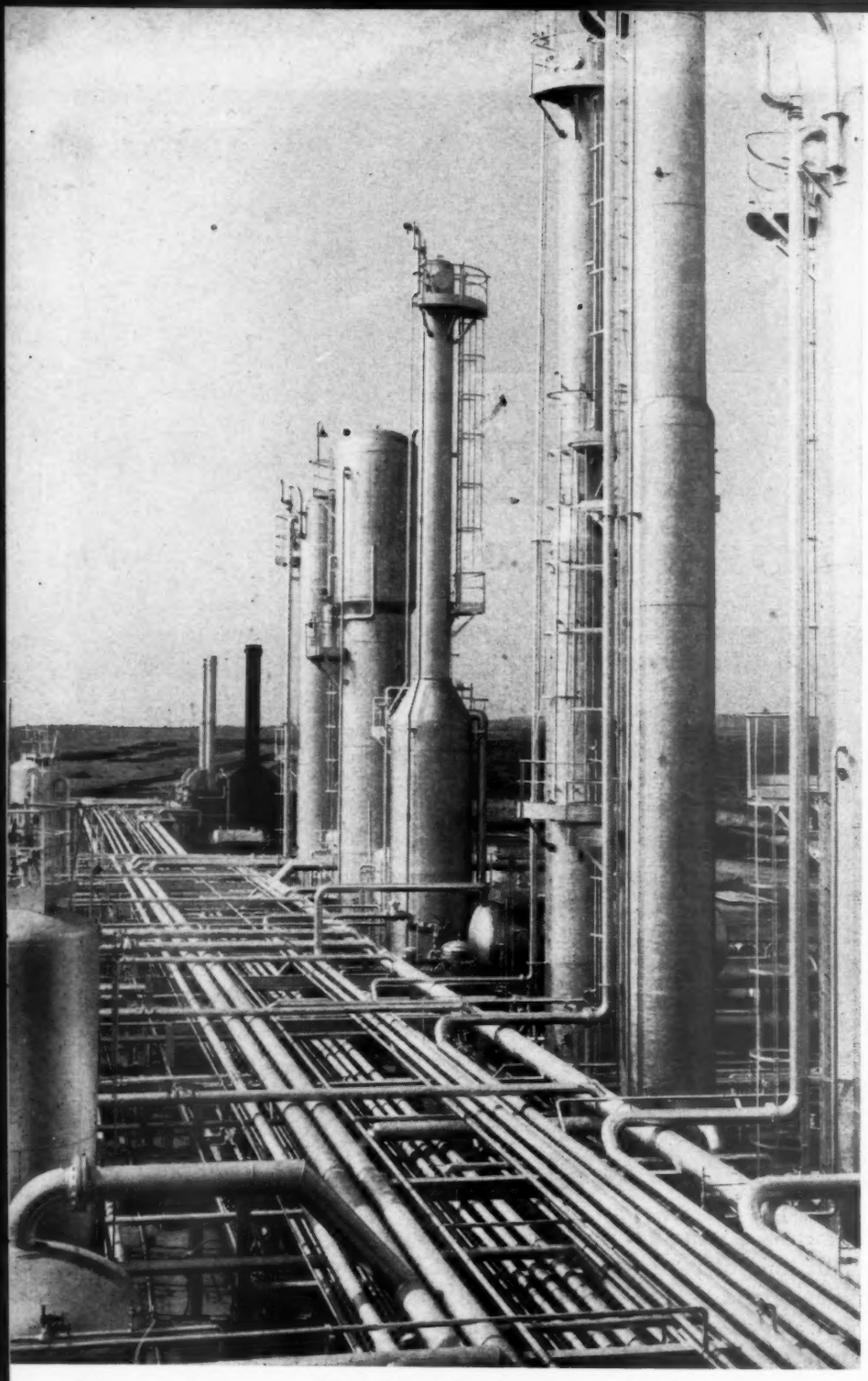


Columns at the new gas plant at Naval Petroleum Reserve No. 1 in California.

Mothballing a Gas Plant

Elk Hills Naval Petroleum Reserve gets standby processing unit for emergency

RICHARD SNEDDON*

EXCLUSIVE

THE people of the United States have just received an added measure of national protection, of which, however, they are probably up to the moment entirely unaware. Recently completed by Standard Oil Company of California, and immediately wrapped in cellophane, as it were, is a new gas processing and pressure maintenance plant on Naval Petroleum Reserve No. 1, which encompasses the Elk Hills field, just north of Taft in California's San Joaquin Valley. "Mothballing," they call this business of shutting in and preserving the plant for future use, and its purpose is to maintain the facilities in usable condition so that in an emergency, they can be placed in operation quickly and effectively.

Capacity of the plant is some 50,000,000 cu ft per day, and it took the construction crews 11 months to build it. As soon as the final touches had been applied in November 1952, and a series of test runs had indicated that everything was in good order (no load tests were made), the mothballing process was begun. Wherever it was considered advisable and economically feasible, vulnerable equipment was treated, or disconnected and stored, to assure minimum damage from exposure during the shut-down. The only units permitted to remain in an operable status were the fire-fighting system and the lighting system.

According to present plans, the new gas plant will never be required to go into full operation, unless the Naval Reserve's shut-in wells are opened up, and that is only likely to occur in the event of an all-out war. If all the wells should be opened up, Naval Petroleum Reserve No. 1 could produce approximately 100,000 bbl a day of crude oil—more than 10 per cent of the state's current daily production total. Crude oil reserves at Elk Hills, incidentally, are conservatively estimated at 650,000,000 bbl, almost twice the estimated reserves of any other California field.

If the gas production from future Elk Hills wells is sufficiently high to warrant such a step, the new plant may have to be operated at limited capacity. Until that time, however, such gas as must be produced will be processed at an existing plant which is capable of handling 3,000,000 cu ft of gas a day. This production becomes available as a result of the "readiness" program, which holds already completed wells in constant ready-to-produce condition, and also derives additional gas from the testing of new wells, drilled under an operating agreement that exists between Standard Oil Company and the Navy.

When the new plant actually goes into operation, the existing plant will be used as a booster station. It is currently processing about 1,750,000 cu ft of gas a day and producing about 1000 gallons of gasoline a day. That leaves a capacity of 1,250,000 cu ft of gas a day to be used up before it should be necessary to consider partial employment of the

*Pacific Coast Editor.

new facilities, to handle such further quantities of gas as may from time to time be produced under the operating agreement. It might be noted, by the way, that the old facilities are quite inadequate for the manufacture of other types of fuel.

Cost of the new plant, with its gathering system, is in excess of $6,000,000, a portion of which is attributable to the mothballing of the equipment and machinery. The allocation of this cost between Navy and Standard of California, the operator, will be on the basis of plant design. And, speaking of plant design, it is an interesting feature of the overall layout that its eventual enlargement to a 100,000,000 cu ft a day plant has been anticipated, and the necessary facilities to accomplish that end with the least possible interruption of schedule have been provided for.

The new plant was constructed by Parsons-Macco Company of Los Angeles, under the supervision of Standard Oil Company of California, and is situated at the intersection of the Taft-Buttonwillow Highway and Elk Hills Skyline Road, in the southwestern portion of the 46,000-acre tract that constitutes Naval Petroleum Reserve No. 1. The 100 miles, more or less, of gathering and injection lines, ranging from 2⅜ in. to 16 in., that were required to integrate the system, were laid by Engineers Limited Pipeline Company.

With wall thickness varying according to function, these lines were of the following sizes and approximate lengths: Two and three-eighths, 99,000 ft; three and a half, 125,000 ft; four and a half, 109,000 ft; six and five-eighths, 74,000 ft; eight and five-eighths, 44,000 ft; ten and three-quarters, 60,000 ft; and 16 in., 45,000 ft.

The plant consists essentially of seven units, including an absorber, rich-oil rectifier, stripper, de-ethanizer, de-propanizer, de-butanizer, and de-iso-butanizer. Additional equipment that had to be considered in the mothballing program were seven 880-hp Clark compressors; two 20,000 lb per hour boilers, supplied by United Iron Works; one 19,000,000 Btu per hour rich oil furnace; 20 pumps; and about 40 feed drums and reflex drums for the columns. Considerable portion of the cooling will be done by Hudson fin-tubed air exchangers.

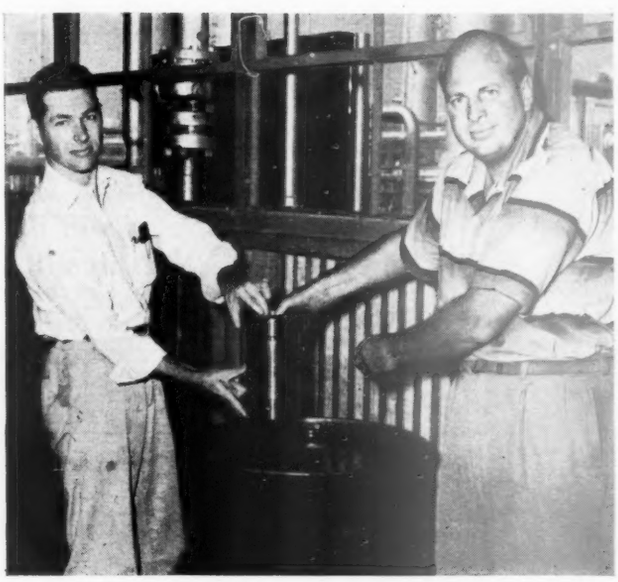
The plant capacity of 50,000,000 cu ft a day may be translated into end products of 45,000 gal of gasoline, 48,000 gal of propane, 26,000 gal of butane, 15,000 gal of iso-butane, and methane. Storage has been provided for 50,000 gal of gasoline, 75,000 gal of butane, 50,000 gal iso-butane, and 50,000 gal propane.

Immediately after the completion of

Clark compressors in the new gas plant are 880 hp.

V. O. Wankowski, Standard of California's member of the two-man operating committee for NPR No. 1; Commander W. M. Gustafson, inspector of Naval Petroleum Reserves in California; Commander F. W. Gooch, assistant inspector. Standing, W. A. Walker, U. S. Navy's representative on operating committee.

John Ziebarth, left, and John Park hold up a valve packer which, with other critical parts from the compressors, has been stored in barrels of preserving oil.



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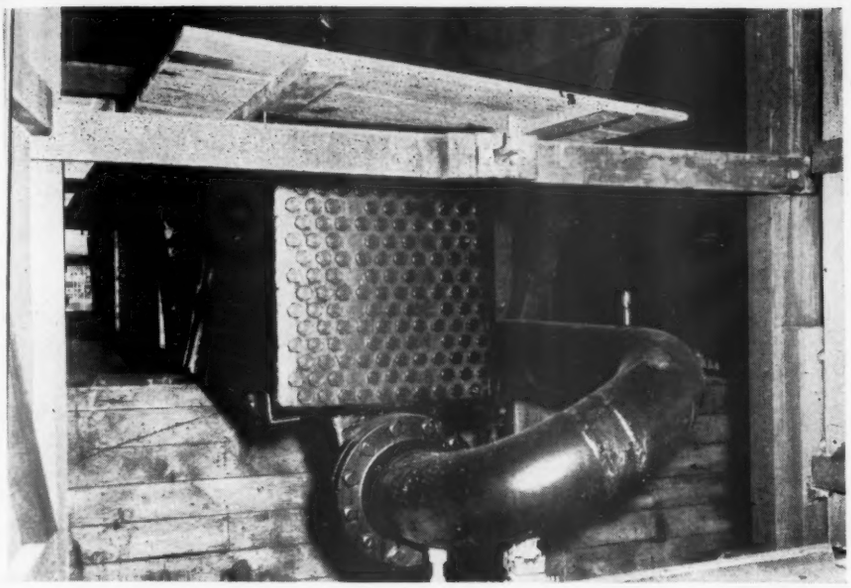


Cooling sections. Note the baffle over the top of the coils, which have been sprayed over with preserving oil. It is to prevent water from falling on the coils.

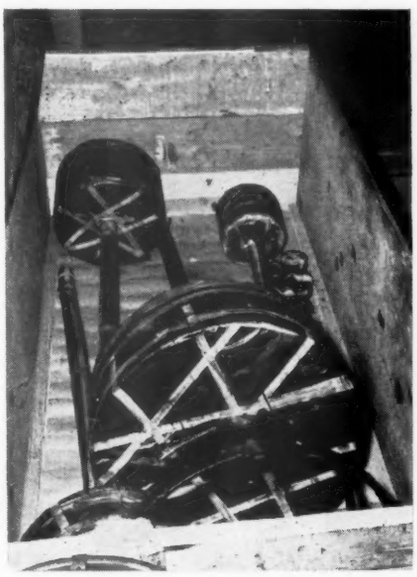
the test runs on the plant, it was shut down and the mothballing process was commenced. All items of equipment that might be damaged by moisture, including, for example, electric motors, precision recording and control instruments, and electrical switch gears, were disconnected and transferred to heated buildings, to prevent deterioration from corrosion or other deleterious influence.

Preservative oils and protective covers were used where there was any likelihood of rust developing, and when and where necessary, equipment was disassembled, treated, and stored. Equipment was treated with cosmoline or with lubricating oil of high detergency. In the case of pumps, motors were removed and stored, and electric lines were disconnected. Then preserving oil was put in the pump cases and protective grease was applied to external surfaces. Desiccants were put in the indicator boxes of various instruments to absorb atmospheric moisture.

Cooling sections of the towers were sprayed with preserving oil, and baffles were placed above the coils to prevent water dripping on them. When it becomes necessary to return these coils to service, the oil will be removed with a solvent spray. In the meantime, the mothballed plant will be patrolled constantly by one man, probably an experienced roustabout, who, besides serving as watchman, will do much miscellaneous maintenance work as may be required.

Plant piping and all of the columns with the exception of the absorber, were designed for double the present capacity. The piping layout also was so arranged that when the time comes to realize the full capacity of the plant, the necessary additional compressors can be tied in with a very minimum of shut-down time.

In order to double the projected throughput of the plant as it now stands, the following would require to be added: One boiler, one furnace, one absorber, additional compressors, and a cooling tower with twice the prevailing capacity. It would also be necessary, of course, to augment considerably the present storage facilities.



Mothballed pistons, boxed for storage in the compressor house.

During the construction of the plant, John Park, Standard Oil Company of California, acted as engineer, and was assisted by John Ziebarth, also of Standard Oil Company of California.

Members of the two-man operating committee for Naval Petroleum Reserve No. 1 are W. A. Walker, representing the United States Navy, and V. O. Wankowski, representing Standard Oil Company of California. Commander W. M. Gustafson is inspector of Naval Petroleum Reserves in California, with offices at Elk Hills. Assistant inspector is Commander F. W. Gooch. * * *

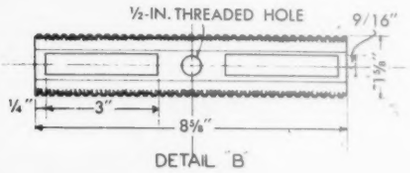
PLANT AIDS

Gear or Coupling Puller[2]

TOM SIEFKES†

When confronted with a coupling on a pump shaft that we were unable to move with conventional pullers available, a gear or coupling puller was constructed to do the job. See drawing for details of construction and material needed.

In use the puller jaws are slipped over



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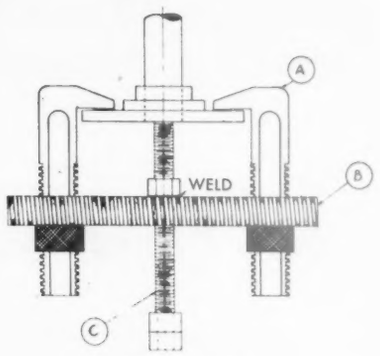


GEAR PULLER

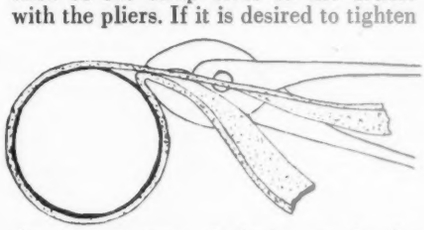
the coupling, the knurled nuts on the jaws are adjusted until the bar is parallel with the coupling, pressure is applied by turning the 6-in. center bolt against the center of the pump shaft until the frozen coupling or gear is removed. With the exception of the center bolt, this instrument is made entirely from discarded Stillson wrenches.

[2]Class A, second prize, NGAA—Panhandle-Plains Regional Meeting, Amarillo, Tuesday, November 20, 1951.

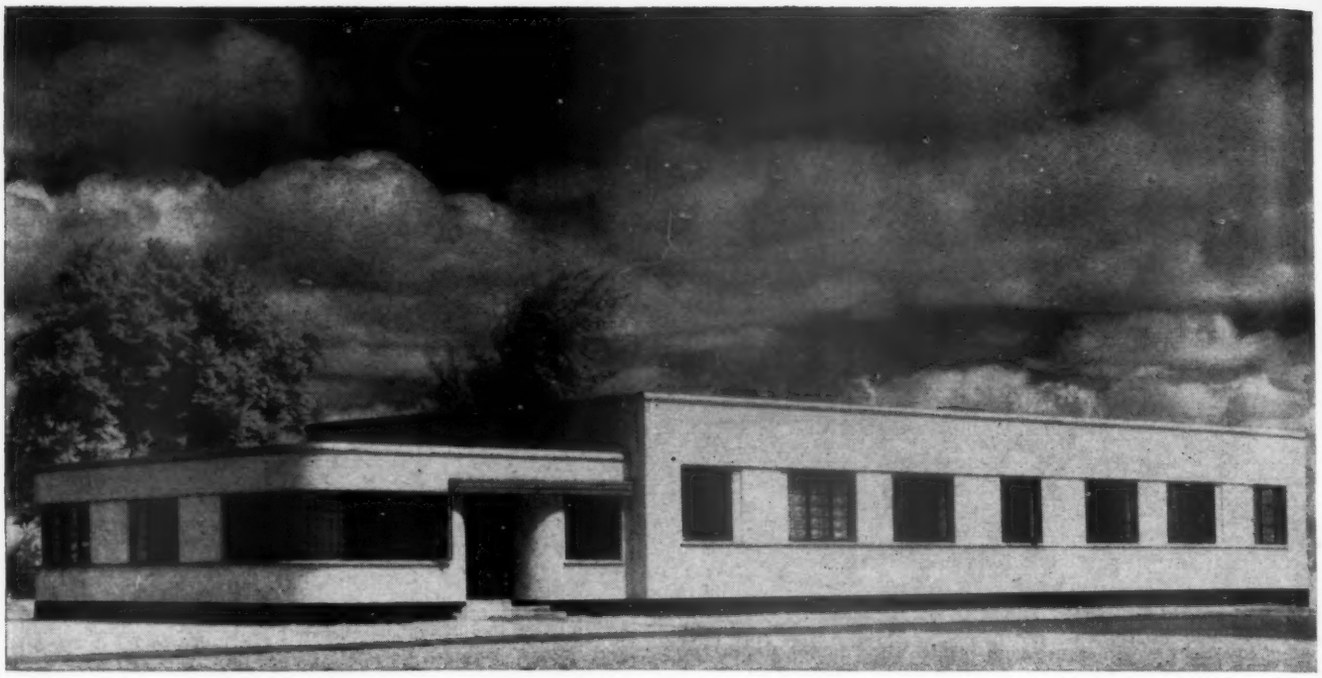
†Shamrock Oil and Gas Corporation.

Leather Pliers 'Pipe Wrench'

It is to make a good "pipe wrench" out of a leather strap and a pair of pliers. Wrap the strap around the article to be turned, as shown, and grasp both ends of the strap close to the article with the pliers. If it is desired to tighten



the thread, turn clockwise, as in the sketch. If the thread is to be loosened, simply pull the other way just as with any regular wrench. This idea is of special value where the article is nickeled or polished and must not be scratched as the leather forms a cushion between the pliers and the metal. If a single thickness of leather is not strong enough, use two thicknesses, or more. Or, use any other strong flexible material—even a rope.—W.F.S.



New Subzero Tool Oil Developed

National Research Council gas and oil laboratory carries out research on fuels, lubricants, greases and hydraulic fluids, such as special lubricant for use in pneumatic rock drills and jackhammers in temperatures — 50 F to + 40 F

HARRY CHAPIN PLUMMER

COMPLETION of a new low temperature oil as a lubricant for use in pneumatic tools, such as rock-drills and jackhammers, where water or wet air is present, is announced by the National Research Council Canada and listing by the Canadian Government Specifications Board following field tests. The definition applies to a lubricant serviceable in temperatures ranging between + 40 F and - 50 F.

The general requirements are that the lubricant shall be well refined petroleum oil in which additives may be incorporated to fulfill the requirements with respect to film strength and steam emulsion value. The requirements are set forth as "absolute and * * * not subject to correction for tolerance of the test methods." If multiple determinations are made, however, average results will be used.

Physical and chemical requirements.

	Min.	Max.	Test method
Pour point, F	....	—55	28.2
Flash point, F	300	....	27.1
Viscosity at 100 F Kinematic, Centistokes	11.5	....	36.1
Viscosity at 0 F Kinematic, Centistokes	....	500	36.1
Viscosity index	75	....	37.1
Carbon residue, per cent	....	0.2	41.2
Strong acid number	....	Nil	2.1
Free fatty acid (as oleic), per cent	....	0.40	2.1
Sulphate residue	....	0.10	42.9
Steam emulsion number	1200+	....	50.1
Film strength, psi	8000	....	57.1

Steam emulsion number—for operation below 30 F, ambient temperature, this requirement may be waived.

Sampling and Test Methods. A sample of not less than two Imperial quarts shall be provided for tests and shall be obtained in accordance with Section 1.3 of Schedule No. 3-GP-O; Methods of Testing Petroleum and Associated Products.

Testing. The methods of testing shall in all cases be those described in Schedule No. 3-GP-O, using the procedure specified with each requirement.

Related Specifications. For a summer grade of this type lubricant see Specification No. 3-GP-363.

3-GP-363 Specification applies to a lubricant for use in pneumatic tools at atmospheric temperature above + 40 F * * * shall be a well refined petroleum oil specially treated to provide the specified consistency and high film strength. "Requirements absolute * * * not subject to correction for tolerance of the test methods." If multiple determinations are made, however, average results will be used.

EXCLUSIVE

Physical and chemical requirements.

	Min.	Max.	Test method
Pour point, F	....	15	28.2
Flash point, F	380	....	27.1
Viscosity at 100 F Kinematic, Centistokes	97.4	119	36.1
Approx. S. U. seconds	450	550	36.2
Carbon residue, per cent	....	0.35	41.2
Strong acid number	....	Nil	2.1
Free fatty acid (as oleic), per cent	....	0.40	2.1
Consistency	Stringy		
Metallic soap	....	Nil	42.1
Steam emulsion number	1200+	....	50.1
Film strength, psi	12,000	....	57.1

Performance Requirements. In addition to meeting the above general and detailed requirements, the lubricant shall prove satisfactory in service.

Sampling and Test Methods

Sampling. A sample of not less than two Imperial quarts shall be provided for tests and shall be obtained in accordance with Section 1.3 of Schedule No. 3-GP-O: Methods of Testing Petroleum and Associated Products.

Testing. The methods of testing shall in all cases be those described in Schedule No. 3-GP-O, using the procedure specified with each requirement.

Related Specifications. For a low temperature grade of this type of lubricant see Specification No. 3-GP-53a, described above. * * *

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GASOLINE PLANT DESIGN

PART 9 — EXPANSION AND FLEXIBILITY

O. L. LEWIS*

EDITOR'S NOTE — This article is the last in the series by this well known author, covering an important subject with latest developments in plant design.

In the last few years, piping expansion and flexibility has been as popular a subject among technical writers in the petroleum industry, as immorality has been among fiction authors. And like the weather, the basic problem is still with us. We are only learning to live with it more comfortably. Scientists and technical engineers constantly give us refined methods of calculation for more closely approaching an exact theoretical solution. This is fine. There are no short-cuts to exact solutions. And without proper understanding of variables involved, short-cuts for practical use cannot be intelligently utilized.

There are many references dealing with calculation of expansion and flexibility. There is not nearly so much information available on how and where to apply these calculations. The choice of calculation method is left to the individual and the circumstances. We try to point out where stress and force might be critical. And suggest possible remedies when excessive force or stress may be present.

Expansion

Effect of Expansion. Expansion forces are critical primarily at the ends of lines. We need to check forces at connections to equipment such as pumps and compressors. And at nozzles on vessels and exchangers. These points are not normally the point of highest stress in the lines but the end forces may be larger than allowable. Points of highest stress are usually not at the terminal point of a line but are found at points of change in direction or reduction in size. Watch ells, tees and swages for excessive stress. The maximum stress is not always actually in the fitting but may be in the pipe adjacent to the fitting. Moment itself may be critical in a line where force and stress are well within limits. This condition would only be anticipated where there is a change in line material. Control valves and cast iron valves and fittings are susceptible to excessive moment. The moment reaction definitely affects the seal, gasket pressure and bolt stress in a flanged joint.

Expansion Forces. The magnitude of the end force generated by temperature change in a straight section of pipe is dependent upon temperature difference, modulus of elasticity and metal area. The unit expansion is listed in most tables in inches per 100 ft.

This tabulated figure divided by 1200 gives a consistent unit of inches per inch. This figure multiplied by the modulus of elasticity gives pounds per square inch. Then the psi due to temperature difference multiplied by the cross sectional area of the pipe gives total end force generated. Only 170 deg of temperature difference in a 10-in. pipe will cause a corresponding end force of about 200 tons.

The components of the expansion forces react upon the equipment connection unless some provision is made to counteract these forces by external means. The forces on rotating equipment nozzles are particularly critical. Undue or accelerated wear and even failure of pumps and turbines can often be traced directly to piping expansion force that is not controlled. Some pump and turbine manufacturers specify that no piping forces be imposed upon the equipment. Sure, that is an ideal condition but one very difficult to satisfy. So all we can do is to design the piping and anchors so that the forces acting on the equipment are held to a minimum. Then tell the equipment supplier the magnitude of the forces involved and get his approval. Every effort should be made to hold the vertical and horizontal force components so that neither exceeds the weight of the equipment. The forces on large cast iron equipment of course must be way less than this.

There are several ways to control the end forces. First the weight of the piping itself should be carried by external supports. The line can be arranged and cold sprung so that the vertical components due to weight and expansion are negligible under operating conditions and within reasonable limits when the installation is cold. Base ells are a common method of restricting both the vertical and horizontal force components when the distance from pipeway to equipment is too great for proper stability. Base ells, when used, should be arranged to control piping forces without unduly restricting expansion of the pump casing itself. That is one of the disadvantages of a base ell. At times an adjustable support attached to a flange on the ell becomes desirable. Any adjustable support is subject to the human factor of neglect. The support may never actually be adjusted to the hot or cold position. Or once adjusted to one position it may never be changed. So we cannot depend on it entirely to prevent excessive thrust.

Turbines are subject to the same force consideration as centrifugal pumps. In a gasoline plant the turbine case is usually iron. The exhaust line is large and stiff compared to other piping. One factor eases the problem a little. We are dealing with steam instead of hydrocarbon, and expansion joints can be used with more satisfaction. Piping 3-in. and smaller can be arranged for minimum forces without expansion joints in most installations. The high pressure steam to a gasoline plant turbine is probably not larger than 4-in. and built-in piping flexibility is still preferable to an expansion joint. Exhaust steam lines are normally larger and more suited to the use of low pressure expansion joints. The copper bellows joint used in conjunction with a base ell anchor is a suitable answer for most exhaust lines 4-in. and larger. The joint keeps the external load off the turbine and prevents high frequency turbine vibration from being transmitted to the piping system. The internal pressure tends to flatten out the expansion joint bellows. The end thrust is equal to the maximum cross sectional area of the bellows times the maximum steam pressure. The anchor must be designed for this thrust. If the expansion joint thrust due to internal pressure is too great for the turbine casing, an expansion joint with restricted movement or tie bolts is required.

Expansion Stress. Stress in the piping system is due to internal pressure, external loading, and expansion forces. The points of highest unit stress are at or near changes of direction and points of branch takeoff. If there is a reduced section in the line, the maximum unit stress can be expected in that reduced section regardless of its location relative to the other components of the line.

The stress due to internal pressure, of course, has first call on pipe strength. The difference between the stress due to internal pressure and the maximum allowable stress is all that is available for stress due to expansion or mechanical force. Next we must support actual pipe and valve weight so that its effect is negligible in the overall consideration. Then we know what the remaining al-

*C. F. Braun Company.

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lowable is for expansion stress.

Now, for example, say that preliminary calculations indicate that a line is overstressed. What can be done about it? The design pressure is set. It cannot normally be reduced to leave more of the allowable stress for expansion. The design temperature is fixed so the total movement of the piping in every direction is fixed. It is not possible to reduce the movement due to expansion by changing pipe routing or anchor locations. The movement is strictly a function of the temperature and the material. Pipe wall thickness has no significant effect on stresses due to expansion. But it affects the forces and moments in direct ratio.

The differential line movement can be adjusted. Cold springing the line reduces the differential line movement. The ASA Code, Paragraph 620d, outlines the restrictions of cold springing. The computed total expansion may be reduced one-third by this means. So as the movement is reduced, the stress is reduced.

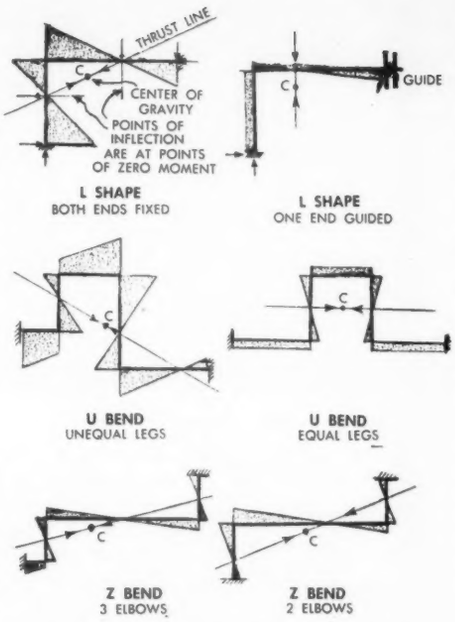
By rearranging the anchor points, the amount of line movement absorbed by different lever arms can be decreased or increased. Rearrangement of anchors is usually the most satisfactory method of reducing stress in a reduced section of the line. Any change in direction adds flexibility and decreases stress in a line. Bends are more flexible than straight pipe. Weld ells are more flexible than bends. But the stress is concentrated as the radius of turn is decreased.

If the point of excessive stress is in an ell, the use of a longer radius bend will decrease the stress but increase the end force components. The change in location of anchors or number of anchor points does not change the total force acting. It does change the direction of thrust and varies the magnitude of the moment arms about the individual points. Members in torsion are about 30 per cent more effective from a flexibility standpoint than similar members in bending.

The only methods of reducing both force and stress in a line is to add additional total offset from a straight line and to add additional changes of direction. Either of these means rearrangement of piping layout. If rerouting of the line is not possible, then some form of an expansion loop can probably be used.

Critical Moment

Fig. 1 shows typical moment diagrams for different piping arrangements. The location of points of no moment and of maximum moment should be kept in mind when locating valves, flanges and equipment in a line. The exact value may not be important as long as the general magnitude is known. If deflection or stress of some item in the piping system is particularly critical, a graphic representation of moment values will be sufficient to properly locate the item where the deflection will not be excessive. If the item cannot be located in a low moment range, change of anchor point and change of line offset are both



Points of high and low stress are easily visualized by the use of a thrust line diagram. The thrust line passes through the center of gravity and through all points of zero moment. This visualization is an aid to the location of critical joints and valves.

FIG. 1. Typical moment diagrams.

effective in moving the point of critical moment.

Variable Factors in Calculations

Most of the accepted methods of piping calculation are based upon the assumption that the piping-system is broken into sections. Each of these sections are considered indeterminate structures for purposes of calculation. Textbooks define indeterminate structures as *those with conditions imposed which make it impossible to determine moments, stress and shear, by means of static equilibrium alone. They cannot be designed directly.*

Logical assumptions are made to fit portions of a pipeline to this definition. In laboratory tests of flexibility and stress, all the conditions of the definition can be met. In an actual installation these conditions may vary so that the parallel is not exact. This is where design-judgment enters the picture. Through familiarity with the effect of varying factors in the exact analysis, we learn which factors can safely be ignored in an approximate analysis.

Actually, the final design arrived at is based entirely on judgment. And the judgment is backed up by one or more of the following: (1) Imagination. (2) Experience. (3) Comparison to existing layouts. (4) Experimentation. (5) Mathematical analysis. The designer must keep in mind that a mathematical analysis is based upon a hypothetical section of piping that more or less resembles what will actually be installed. The designer must use his judgment even in applying the results of analysis to the piping he is designing.

In any analysis it is important to know what is fact and what is fiction, to distinguish between mathematics, statics and assumptions. In the case of assumptions, know under what conditions they are true and when they are not true. On which side of the truth do they err and by what order of magnitude?

Let's look at some cold, hard practical variables for a moment. Most anchor-points in a gasoline plant piping-system are not firm fixed anchors. The line may be anchored to a structural stanchion or to a column or vessel. The anchor-point usually will have some degree of movement in at least one direction unless the line is low and the anchor is actually a concrete foundation.

Pipe is not installed at the theoretical design temperature. Depending upon geographical location of the plant, the assumed installation temperature varies from 32 F to 70 F. Actual pipe installation temperature outdoors in any midwest location may vary from 20 F to 140 F.

The exact dimensions of the fabricated pipe cannot be determined in the design stage. The manufacturing tolerances on fittings and flanges average about ⅛-in. each. Tolerance of vessel diameter and nozzle length are another variable. The actual location of a vessel or tower may vary up to ½-in. All of these variables many times add up to more than the total expansion involved in a piece of pipe.

There are variables in figures that are assumed for the most accurate practical analysis. Pipe wall-thickness may vary 12½ per cent, the modulus of elasticity is an assumed figure. The allowable stress is an assumed figure with a safety factor. Most standardized methods of calculation leave out the effect of the flattening of bends. We ignore the sliding restraint on intermediate supports. As so many variables are beyond the designers control for practical purposes, other assumptions and short-cut methods are justified. The common short-cut methods reduce calculation time from several days to a few hours.

Degree of Accuracy

The primary objective of piping calculations is not always to find exact values, but to ascertain that stress and force do not exceed recognized safe values. Then the degree of accuracy of short-cut methods is not important so long as there is assurance that the results are on the conservative side by only a reasonable degree. Visual inspection and judgment are sufficient calculations for many lines. That is, where reliable judgment has been developed through experience. Easy-to-use charts are an aid. They are a quick way of checking judgment on questionable lines. If the chart then indicates that force or stress may be in a dangerous range, a quick check can be made using one of the acceptable short-cut methods.

Now is the time to *stop*, *look*, and *do something*. If this fast analysis indicates that the line arrangement is clearly satisfactory, fine. If there is any question at all, or if the indicated stress or force is near the maximum allowable, take a good long look at the possibilities

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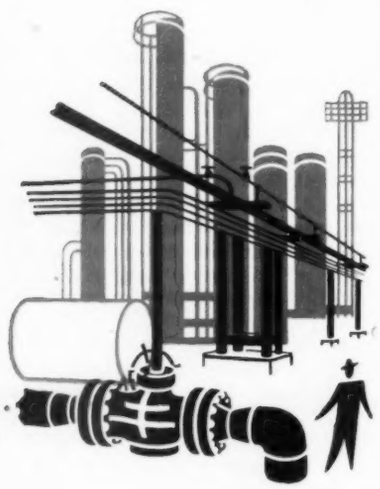

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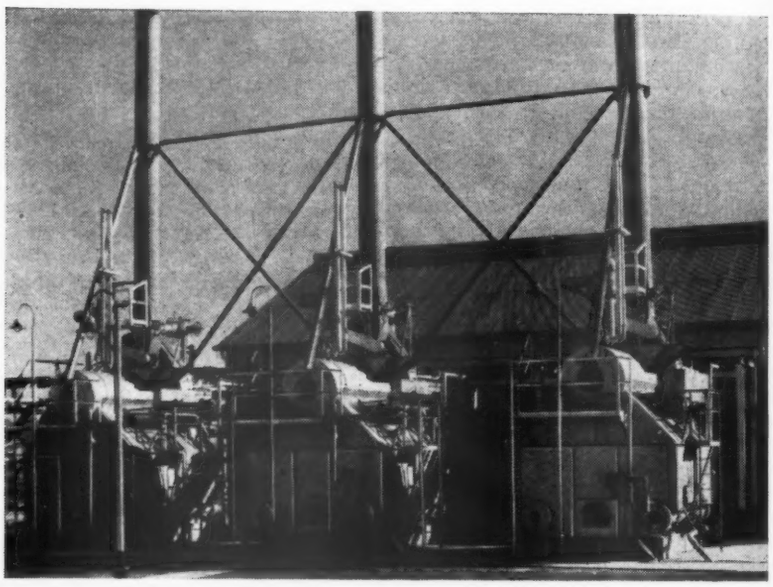

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144

for rearranging the line to reduce these forces. If the line arrangement is the most flexible possible without drastic changes in layout, then a more complete analysis is justified to determine more exactly how safe the installation is. By following this sequence of analysis, 60 per cent of the lines in a plant will be found satisfactory by judgment. Another 30 per cent will be eliminated by quick reference to charts or rule-of-thumb aids. Then only 10 per cent of the lines involved require more detailed analysis.

By using familiar short-cut calculations, most of these lines will be worked out satisfactorily. And probably not more than two or three lines in the plant will require actual detailed analysis. This means that the available time can be spent on the most critical line and the entire piping-system has been subjected to the necessary degree of analysis to insure a satisfactory installation.

Reasonable Doubt

Something like 90 per cent of the lines fall into the judgment and rule-of-thumb category. This is where design background and experience carry the greatest weight. And the greatest time saving in design is possible. The ASA Code for pressure-piping ASA B31.1-1951, Section 6, gives accepted code requirements for absorbing the effects of thermal expansion in a piping-system. The code does not cover methods of calculation or the effect of changing variables. The statement is made that "Formal calculations shall be required only when reasonable doubt exists as to the adequate flexibility of the system." The problem then is to remove the basis for reasonable doubt in the least painful manner.

At times, it is helpful to compare one line to another that has been calculated. These points then are an aid in comparison. The stresses in a piping-system are lower if, (1) the total offset from a straight line is greater; (2) the pipe is smaller, and (3) the temperature variation is less. The pipe wall thickness affects the end forces and moments in direct ratio, but does not have an appreciable affect on bending stress, due to expansion.

The curved components of a piping-system have increased flexibility and stress intensification. The mathematics of analysis is greatly reduced where the corners are considered square. The justification for this practice is the theory that the increased flexibility compensates for the stress intensification. There is by no means complete agreement on this theory and many designers prefer to play on the safe side by using a stress intensification factor, and disregard the increased flexibility. This difference of opinion is responsible for some of the inconsistent variance between results in different methods of flexibility calculation.

The allowable stress is the sum of the longitudinal stress due to pressure and the bending stress due to expansion. The strictly structural stresses caused by the weight of pipe, valves and special fittings, are usually neglected. With proper support spacing, stress due to these factors would not influence the results of analysis.

We need tools as an aid to judgment. The following figures help to understand the effect of the different variables in the piping-system.

Fig. 2, is a handy check for judgment on many lines. The figures shown are not based on any one established method of calculation. They represent conservative results within reason. The figures were calculated on the basis of a single plane 90 deg bend. The flexibility factors indicated for use with additional changes in direction, are arrived at by comparison of the results of many lines of varying length and arrangement. This factor again was chosen on a conservative basis and actual calculation should show more flexibility than indicated by these figures.

Fig. 3, shows graphically the typical variation in stress found in a 6-in. schedule 40 line of 3 different arrangements between the same points.

Fig. 4, showing stress curves for 2-in., 4-in., 6-in., and 8-in. pipe in a right angle line. Here is shown the relative stress of different size lines of identical shape with temperature constant.

PIPE SIZE	LINE TEMP IN. EXP.	100° .5	200° 1.3	250° 1.7	300° 2.2	350° 2.6	400° 3.0	450° 3.5	500° 4.0	550° 4.5	600° 5.0	650° 5.5	700° 6.0
1 1/2"		2'-6"	7'-9"	8'-9"	9'-9"	11'-0"	12'-6"	13'-9"	14'-6"	16'-0"	17'-3"	18'-6"	19'-9"
2"		4'-0"	8'-6"	9'-3"	11'-0"	12'-0"	13'-6"	15'-3"	16'-9"	18'-3"	19'-6"	21'-0"	22'-6"
3"		4'-6"	10'-0"	10'-9"	14'-0"	15'-0"	17'-3"	19'-3"	20'-9"	22'-9"	24'-6"	26'-6"	28'-6"
4"		5'-6"	11'-6"	13'-6"	16'-6"	18'-6"	20'-6"	23'-6"	24'-6"	27'-6"	30'-0"	33'-6"	35'-6"
6"		6'-6"	14'-0"	16'-6"	19'-6"	22'-0"	24'-6"	28'-6"	31'-0"	34'-0"	36'-6"	40'-0"	42'-6"
8"		7'-6"	15'-9"	17'-6"	21'-9"	24'-6"	28'-0"	31'-6"	35'-6"	38'-0"	41'-6"	45'-0"	47'-0"
10"		8'-0"	11'-0"	19'-6"	23'-9"	25'-6"	30'-0"	32'-0"	36'-6"	39'-0"	41'-6"	46'-0"	47'-0"
12"		9'-0"	18'-0"	21'-0"	24'-0"	27'-6"	31'-0"	34'-6"	38'-6"	42'-0"	45'-0"	47'-6"	50'-6"

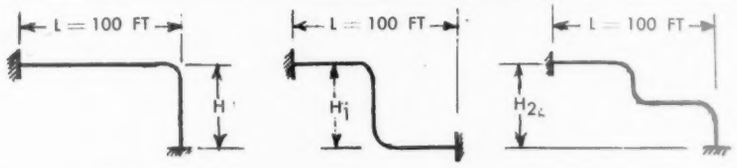

FIG. 2. Approximate flexibility of sch. 40 pipe with long radius weldells at corners.

L = Tabluated value $H_1 = .75 \times L$ $H_2 = .5 \times L$

NOTE: Lines having "L" values equal to or exceeding those tabulated will not be subject to excessive stress, due to expansion, at any point. Where "L" of line is less than tabulated, it should be calculated individually for the conditions involved.

EXAMPLE: A 6-in. line 260 ft long at 400 deg would require an offset of $24.5 \times 2.6 = 63.7$ ft. If the offset as laid out is greater than this figure the line is safe. If the offset is less than this figure the line should be calculated in detail and possible other provisions made to care for the excess expansion.

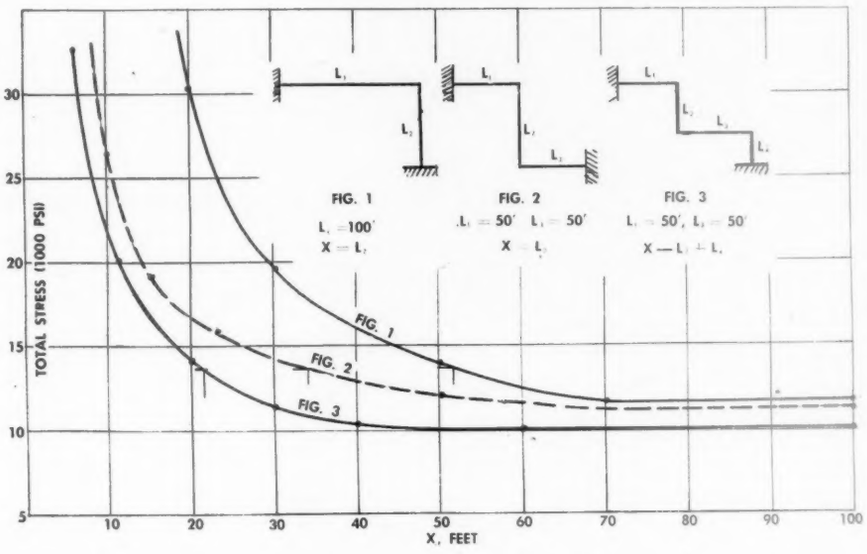

FIG. 3. Stress curves for different shapes in the same plane.

Design Temp. = 500 F Design Press. "P" = 1060 psi Long. Stress due to "P" = 8730 psi

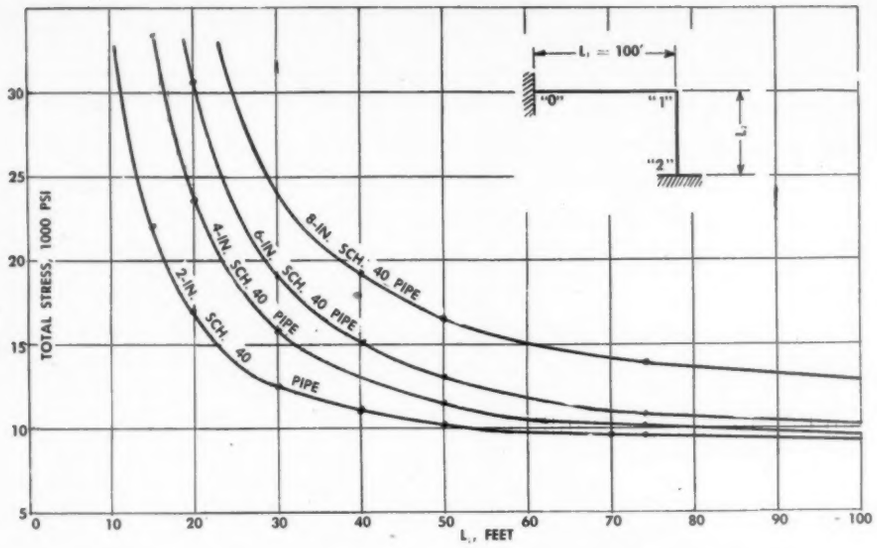

FIG. 4. Total stress curves single plane "L" shape showing variation with size.

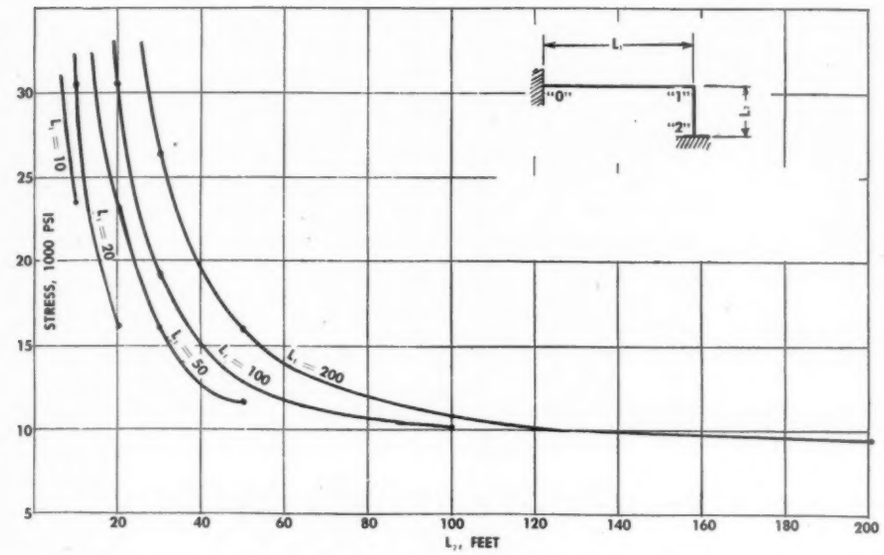

FIG. 5. Maximum stresses in 6-in. sch. 40 pipe as length is varied.

Design Temp. = 500 F Design Pressure "P" = 1060 psi Long. Stress due to "P" = 8730 psi

Pipe Size	Design Temp. F	Design Press. = "P"	Long. Stress due to "P"
2-in.	500	1290	8,720
4-in.	500	1255	8,650
6-in.	500	1060	8,730
8-in.	500	965	10,940

Fig. 5, shows the effect on the stress of the same 6-in. line as the distance from point to point is varied. Fig. 5A shows the effect of additional turns in the same line.

Fig. 6, shows the stress curve for a 6-in. line between fixed points as the temperature differential is varied.

Fig. 7, shows stress curves for different temperatures as the length of the short leg is varied. The maximum allowable stress decreases as the temperature increases. The sloping line crosses the temperature curves at the allowable stress point. These curves point out the trend of stress and force as the design conditions are altered.

Methods of Calculation

Some lines will require more detailed analysis. The mathematical analysis of a line with only two fixed points involves six simultaneous equations. As other restraints are added, the problem becomes increasingly complicated. This complexity has led to the development of several different methods of analysis that are simplified appreciably. The simplified methods are not all uniform and widely differing results are obtained with different approaches. In 1946, heating, piping, and air-conditioning asked several people to explain their favorite method of analysis and to calculate the controlling stresses in two given problems. The properties of the pipe, the shape of the bend, the amount of expansion, and the modulus of elasticity were all given. The stresses arrived at varied from 60 to 140 per cent of the results obtained by true mathematical procedure. The relative accuracy of the methods and the exercise of judgment in the use of the remaining assumptions account for this difference in results. Fig. 8 and Fig. 9, show the results ob-

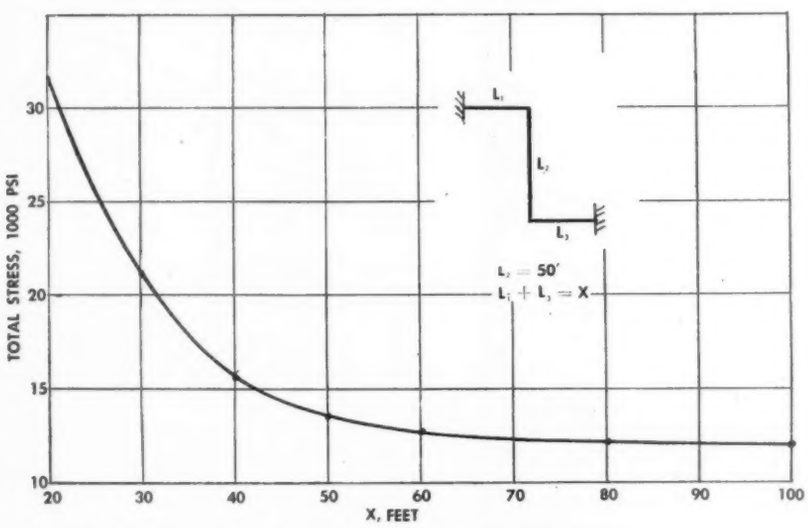

FIG. 5A. Stress curve for varied length of offset legs.

Design Temp. = 500 F Design Pressure "P" = 1060 psi
Long. Stress due to "P" = 8730 psi

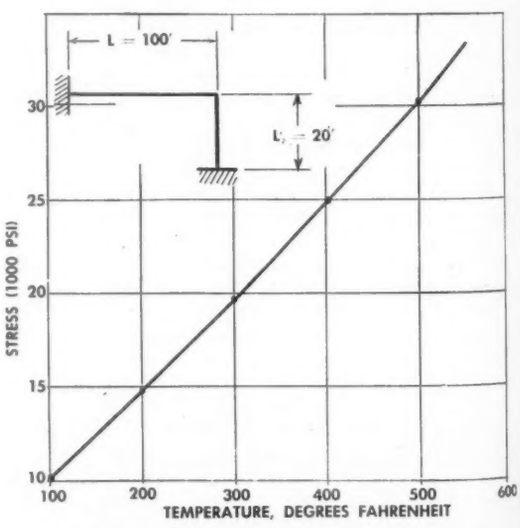

FIG. 6. Stress-temperature diagram 6-in. sch. 40 pipe.

Design Pressure "P" = 1060 psi
Long. Stress due to "P" = 8730 psi

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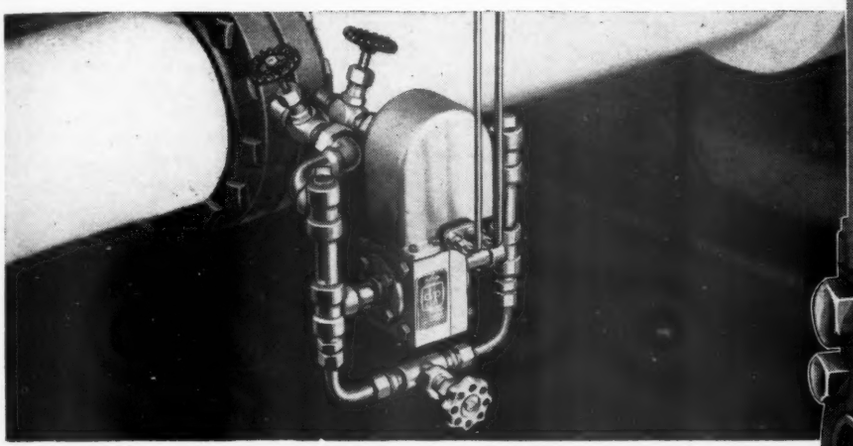

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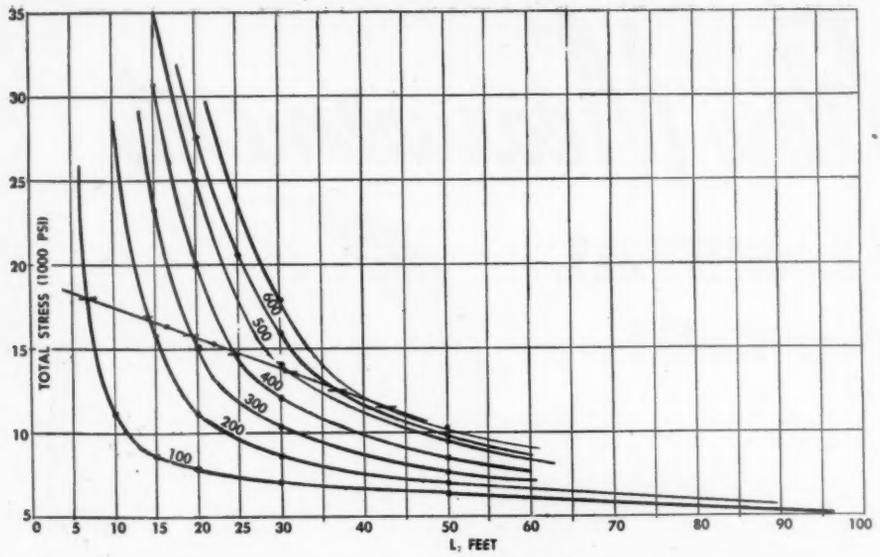

FIG. 7. Total stress curves single plane "L" shape. 6-in. sch. 40 pipe. $L_1 = 100'$. L_2 varies showing variation with temp.

tained by calculations based on five different simplified methods. The old, simple beam equations, $\frac{PL^3}{3EI}$ and $\frac{PL^3}{12EI}$ were used to plot two additional curves. Theoretically, these equations do not apply, and results obtained using them vary appreciably for different size lines. But it is still interesting to note the similarity of the curves to those of some of the simplified methods.

No—these curves do not indicate too much conformity in results. But the simplified methods represented are still much more accurate when applied with judgment than any analysis used only a few years ago. Any of the methods shown are acceptable and will aid appreciably in solving piping design problems. But do not use any of these blindly. Each has applications and limitations, and erroneous conclusions will be drawn if these limitations are not realized and compensated for by judgment applied to the particular problem.

Summary

Piping design is not all mathematics and equations. No calculations are better than the assumptions upon which they are based. Or better than the judgment with which they are applied. Detailed, accurate methods of analysis are required as a basis for judging the application of short-cut methods. But are too time consuming for the degree of accuracy required in gasoline plant work.

Formal calculations are required only when reasonable doubt exists as to the adequate flexibility of the system. A good working knowledge of the following points is the most helpful and satisfactory tool for easily removing that element of doubt. (1) The general magnitude of force and stress that is acceptable under different conditions. (2) Where to expect excessive force and stress. (3) How to avoid conditions that lead to excessive force and stress. (4) How to arrive quickly at the approximate force or stress at a critical point. (5) How force and stress react to changes in piping arrangement. ★ ★

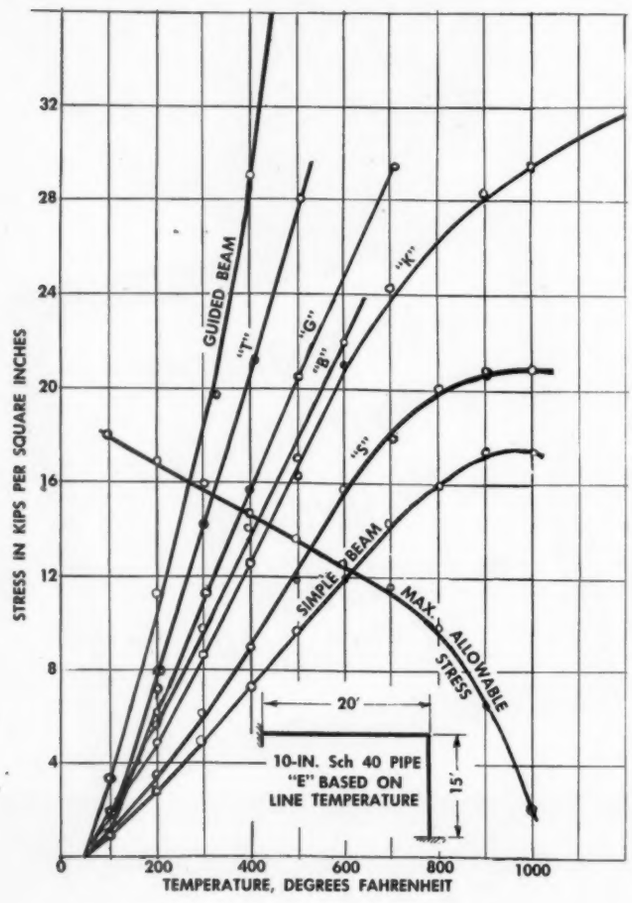

FIG. 8. Stress curves comparing five methods of calculating pipe stresses.

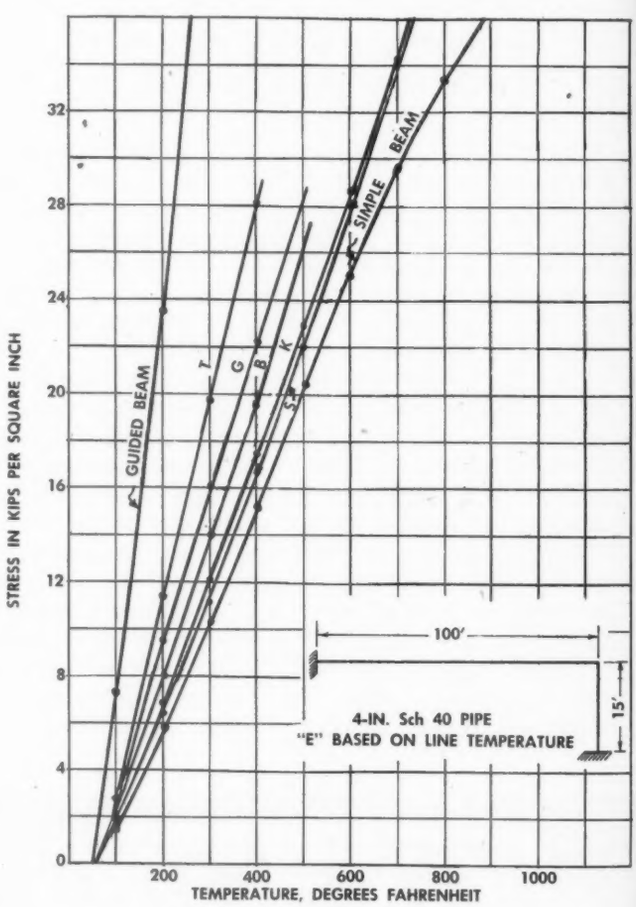

FIG. 9. Stress curves comparing five methods of calculating pipe stresses.

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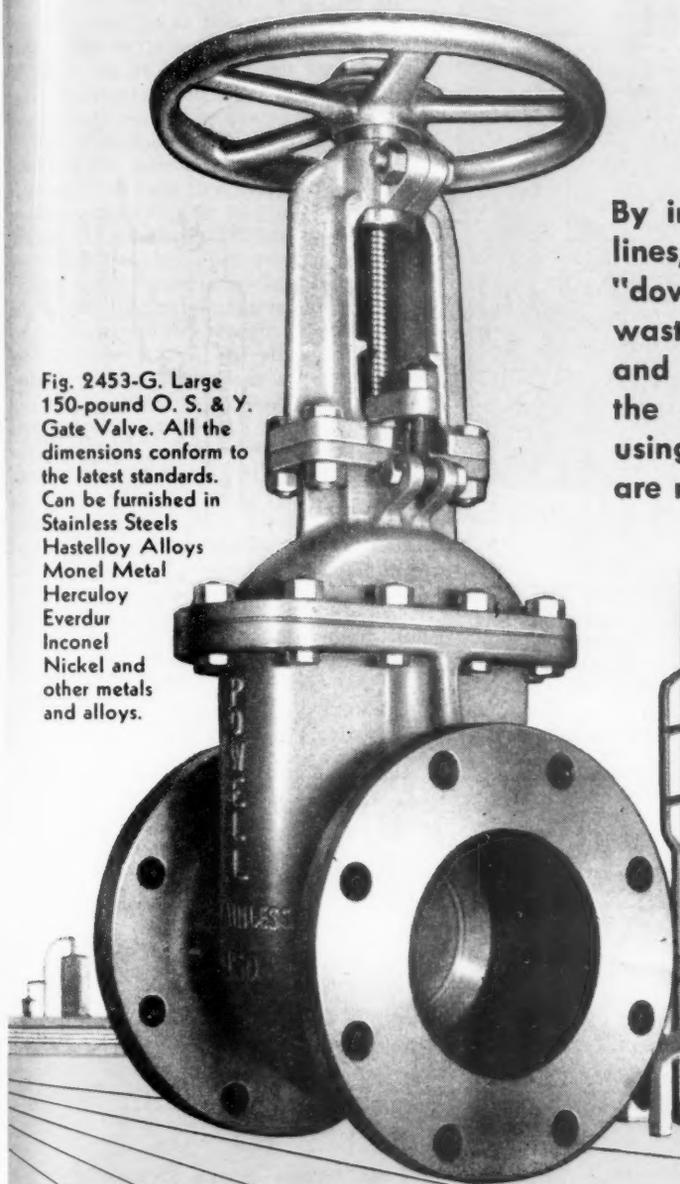

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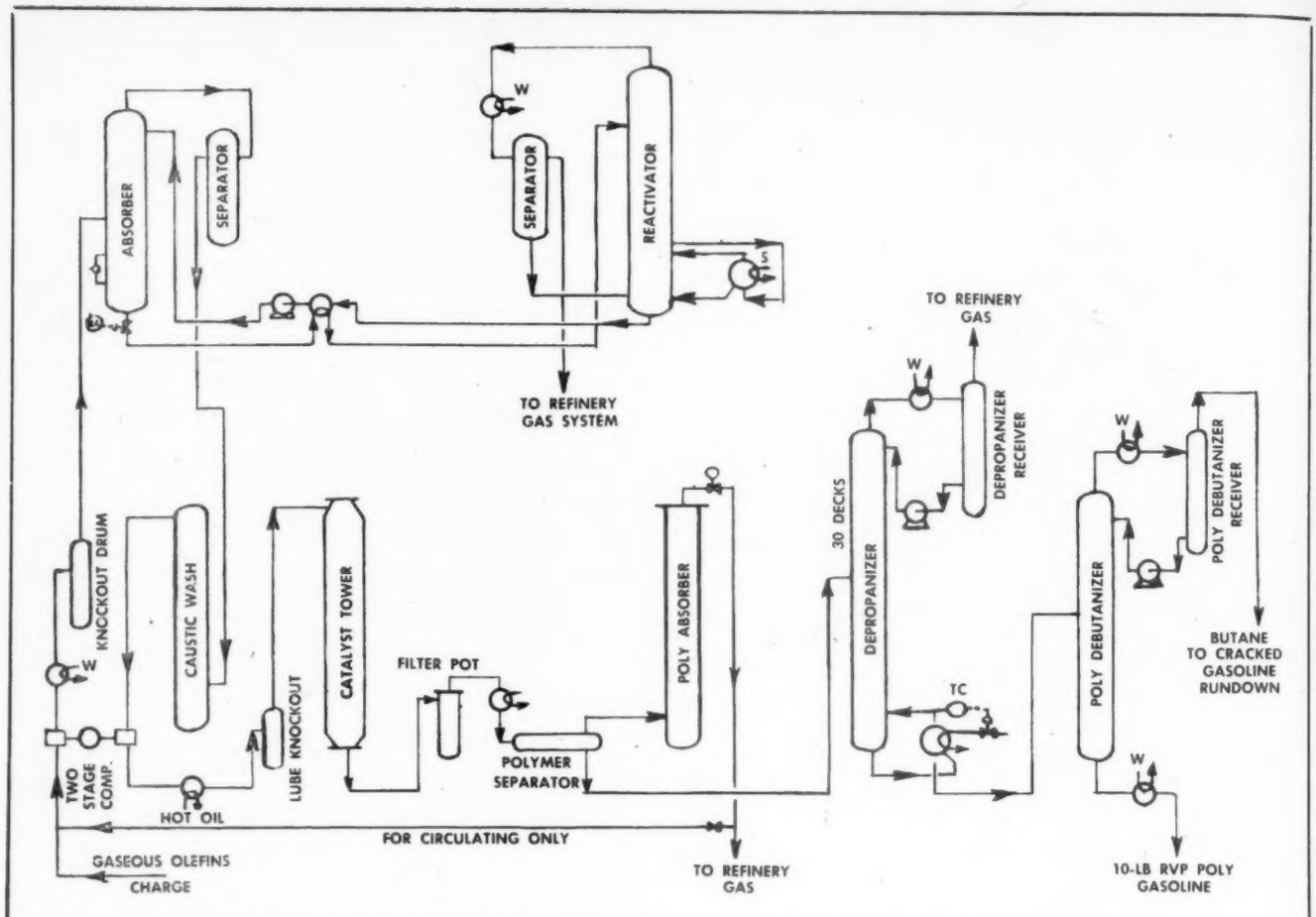


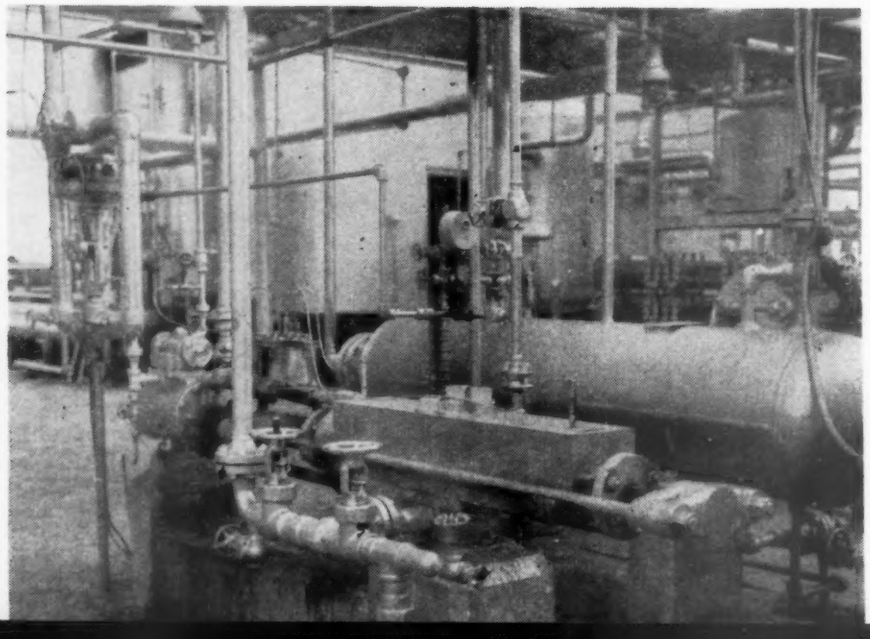
FIG. 1. Flow operations in new poly and desulfurizer units; propane cooling lines to catalyst tower not shown.

Changes and Expansion Boost Yields

Desulfurizer and poly unit raise gasoline production two per cent

ARCH L. FOSTER*

FIG. 2. Poly unit charge pumps.



Two factors in the average refiner's equation are of increasing importance nowadays. There are others, of course, but none more important than these two. Given the facilities for extracting the maximum practicable yield from his crude, especially for motor fuel, his meat-and-bread product, and given the wherewithal for producing the maximum octane rating, sufficient to meet his customers' demands, the refiner can smile and be happy—even though the kerosine market may be "off," or skilled labor tend to drift toward elsewhere.

Onyx Refining Company has been expanding and rebuilding its facilities gradually, while continuing to produce to meet its market requirements. With increased supplies of crude available,

*Editor, Refining and Gas Processing.

EXCLUSIVE

company officials are looking toward more output at a minimum outlay of money in these days of ultra-high unit costs. Some time ago the company rebuilt and increased the capacity of its crude still and its cracking facilities. Plans for the immediate future call for addition of vis-breaking and of catalytic reforming capacity. In fact, the vis-breaker unit is in process of construction. The most recent addition to the plant is its 54,000 cu ft per hour catalytic polymerization unit, which started operations several weeks ago.

This unit, under UOP license and employing the well-known catalyst of that process, has increased the plant yield of motor fuel by almost two per cent. This works out as about 130 bbl per day of polymer, and the improvement of octane rating made possible by this addition of high blending value enables the payout of the unit in a few months according to present operations. The straight octane rating of the polymer is about 94 Research, on the average, while its blending value is somewhat higher.

One two-stage compressor is employed in the unit to handle all olefinic gases to the absorber. All piping in the compressor system is A-53, Grade A carbon steel. In fact, practically all piping in the unit is carbon steel.

The single catalyst tower is 42 in. by 31 ft 9 in. seam-to-seam, and the wall is 1¼-in. in thickness, of A-285, Grade C firebox steel, with no lining. All connections are designed and tested for 550 psig working pressure. The absorber is 18-in. diameter by 20 ft long, without bubble-cap trays, and designed for 500 psig. The depropanizer contains 30 trays and is 2 ft 6 in. by 56 ft 4 in. Absorber oil is handled by the Poly absorber lean oil 9 in. by 2⅛ in. by 12 in. Simplex, ram type pump, shown in Fig. 2, which circulates the oil at about 10 gal per minute through the absorber. Exchange is accomplished largely in E-R G-Fin units as shown in Figs. 3 and 4. The unit naturally is mainly automatic, control being carried out mostly with such instruments as Fisher diaphragm values, Fig. 5 (a and b).

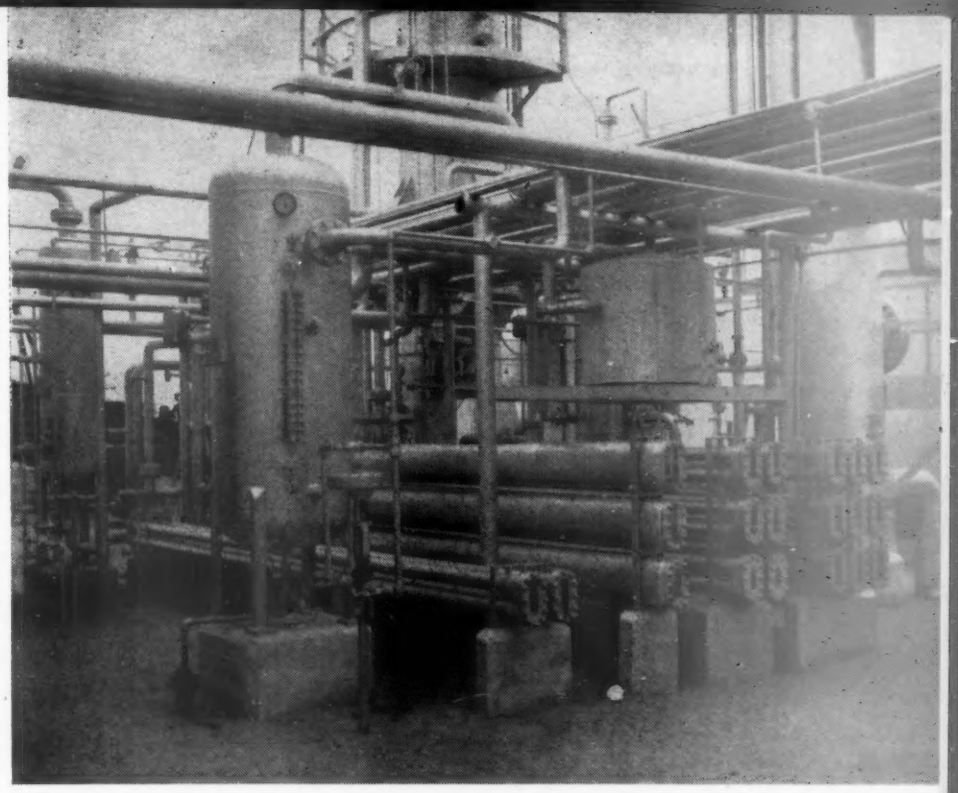


FIG. 3. Tubular heat exchangers in new catalytic polymerization unit.

Operating Routine

The charge stock is fairly sulfurous, containing, as a typical figure, 283 grains per gallon or about 3.4 per cent as hydrogen sulfide in vapor form. Some of this sulfur is in mercaptan form, up to about 15 grains of the 283 total. The operations in this system are shown clearly in Fig. 1.

Two streams of vapors are charged to the compressor lines. One comes from the stabilizer overhead, and the other from the pressure distillate gas accumulator, the two together making about 54,000 cu ft per hour. The stabilizer overhead stream contains about 46 per cent of propylene and butylenes. The pressure distillate accumulator stream contains only about 21 per cent of olefins. With extraneous non-olefinic vapors the combined inlet stream to the compressor shows about 16-17 per cent olefins with the stripped outlet vapors retaining only about 2 per cent olefins, this composition being in approximate equilibrium under the operating conditions with polymer in the unit. The raw gases pass through the Girbotol desulfurizing unit at about 120 F, out at 145 F, with the reboiler held around 222 F.

The diethanolamine solution employed is about 25 per cent concentration, which serves satisfactorily. To this is added as needed about 8 oz (liquid) of Ocenol as an anti-foam agent, serving to prevent entrainment and foaming of the amine solution with consequent carryover and loss.

The vapors go into the first stage of the compressor at about 38 psig, discharge at about 150 psig. From the second stage the vapors at about 515 psig. enter the top of the catalyst column at about 425 F, along with a small fraction of a per cent of water vapor. This addition of water maintains the catalyst at the degree of hydration, which is optimum for maximum reactivity of the phosphoric acid catalyst. The amount of water used is negligible.

Another operation carried out successfully with definite advantage is the in-

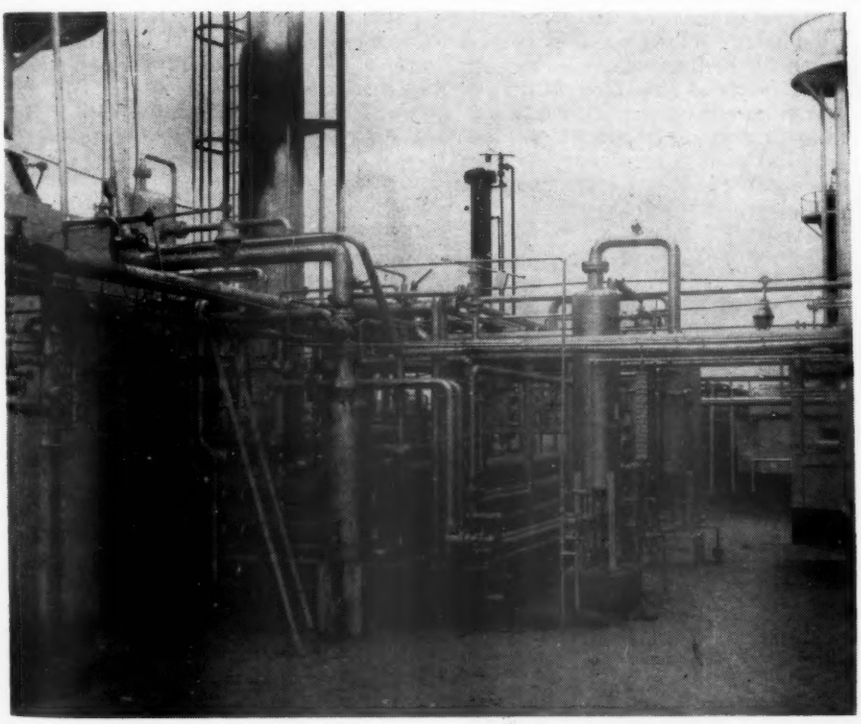


FIG. 4. Absorber and reactivator columns for desulfurization unit.

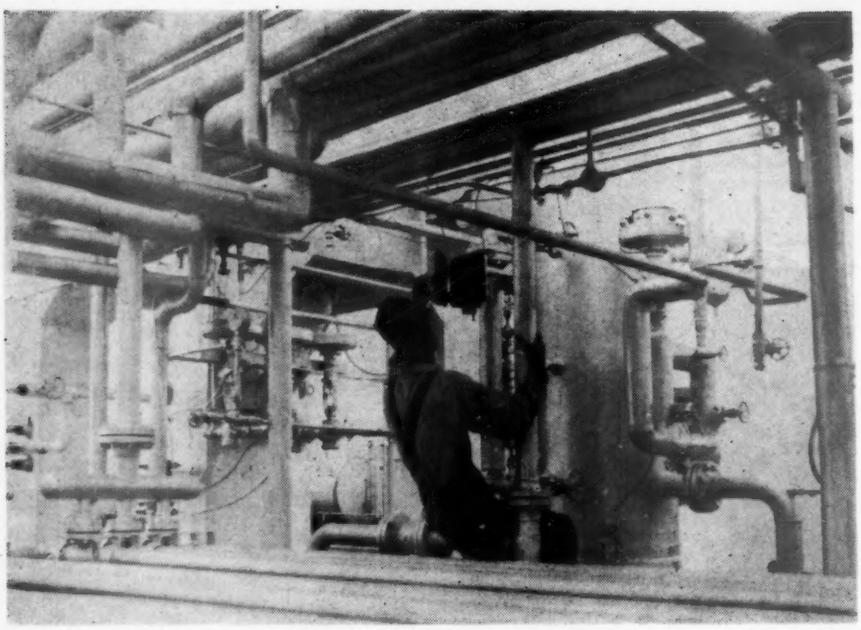


FIG. 5a. Operator of poly unit checking instruments.

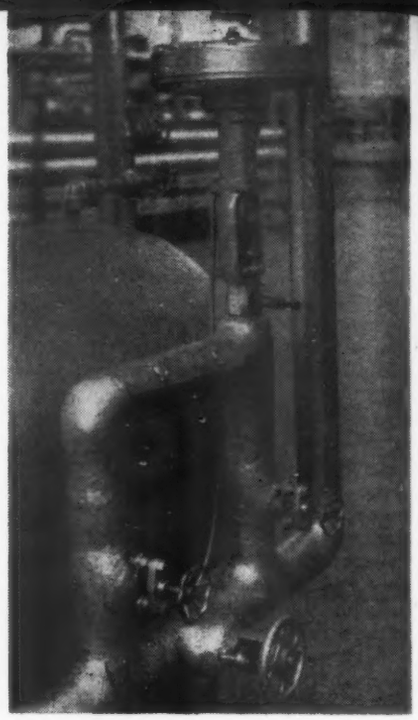


FIG. 5b. Flow regulator.

jection of propane into the reactor to reduce the temperature "climb" between catalyst beds. Liquid propane is injected between the second, third and fourth beds and evaporates to cool the charge mass. The reaction of polymerization is exothermic; the operating temperature range of 420-455 is found to be approximately the optimum for all considerations, and if this temperature goes up appreciably it detracts from the results obtained, excessive rise in temperature promoting formation of heavier polymers and reducing yields of product in the motor fuel range. Too much temperature means excessive gum. The amount of propane is not predetermined, but is regulated to hold desired bed temperatures for optimum end results.

For typical operations of the reactor the reaction pressures are about 480 psig for the first three beds, which falls to 475 psig in the fourth bed. Temperatures in the catalyst beds are, first bed, 420 F in, 425 out. This efflux is cooled by the propane injection back to 415 entering bed 2, rises to 420 F at exit. For the third bed the charge is cooled to 400 F, but rises to 445 F by reason of the reaction in that bed.

Slight cooling brings the charge back to 440 F for the fourth bed which brings it up to the final 455 F, the average temperature of the exit vapors of polymer and unreacted olefins with large percentages of paraffinic C_3's and C_4's.

The polymer gasoline is reduced in the stabilizer to the desired Reid vapor pressure for blending, going largely into premium grade gasoline. The propane and butanes are separated into the depropanizer and debutanizer, the propane for liquefied petroleum gas having an endpoint of about minus 22 F, the butane boiling normally between 22 and 38 F. Butanes from the debutanizer overhead pass directly into the cracked gasoline steam, all surplus going to the fuel gas stream.

Typical production of polymer gasoline shows the following inspection data:

Gravity, API	67.7
Vapor pressure, Reid	9.6
Gum, ASTM	9.0+
Initial boiling point	94 F
5 per cent distilled	120
10 per cent distilled	132
20 per cent distilled	153
30 per cent distilled	175
40 per cent distilled	198
50 per cent distilled	216
60 per cent distilled	233
70 per cent distilled	255
80 per cent distilled	292
90 per cent distilled	343
95 per cent distilled	402
E. P. distilled	448

This polymer gasoline at present is used mainly in blending with cracked gasoline to make up premium motor fuel, with about 20 per cent of polymer and 80 per cent of cracked gasoline to produce a 91 octane rating fuel (Research).

Typical data on the blending value and TEL susceptibility of the mixed streams are shown below.

Blending data on polymer and cracked distillate blends.

Per cent polymer.	00	5.0	9.5	25.0	75.0	100.0
Per cent cracked gasoline	100	95.0	90.5	75.0	25.0	.....
Research O. N., clear	75.9	76.7	77.9	81.2	90.6	93.8
1cc TEL	83.6	84.2	84.9	87.8	94.7	96.5
2 cc TEL	86.8	87.2	88.0	90.2	96.0	97.4
3 cc TEL	88.3	88.7	89.6	91.6	97.4	98.0

FIG. 6. View of cat poly unit at Hawley.

Thus another step is made in the never-ending "climb" toward higher qualities in motor fuels and other products in this refinery. Plans are afoot regarding a catalytic reformer, which are not yet mature and which may or may not be delayed by general national and international political conditions as they control and interfere with equipment supplies. Vis-breaking and perhaps a vacuum tower will solve another problem regarding the handling and finishing of heavy fuel oil, itself a problem that bids fair to become more, rather than less, perplexing, perhaps vital. Of course another milepost is the installation of a catalytic cracking unit, solution which is expectable for any modern refinery outfit. * * *

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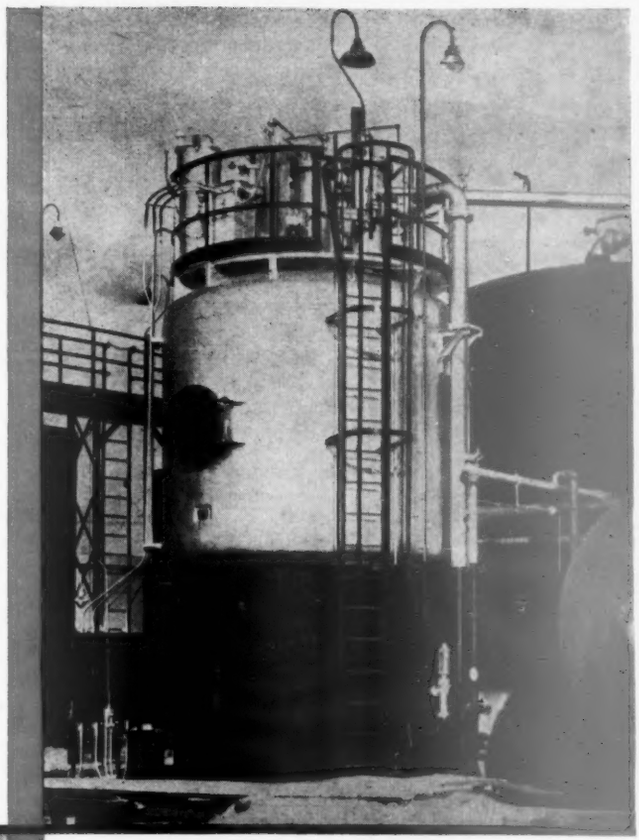

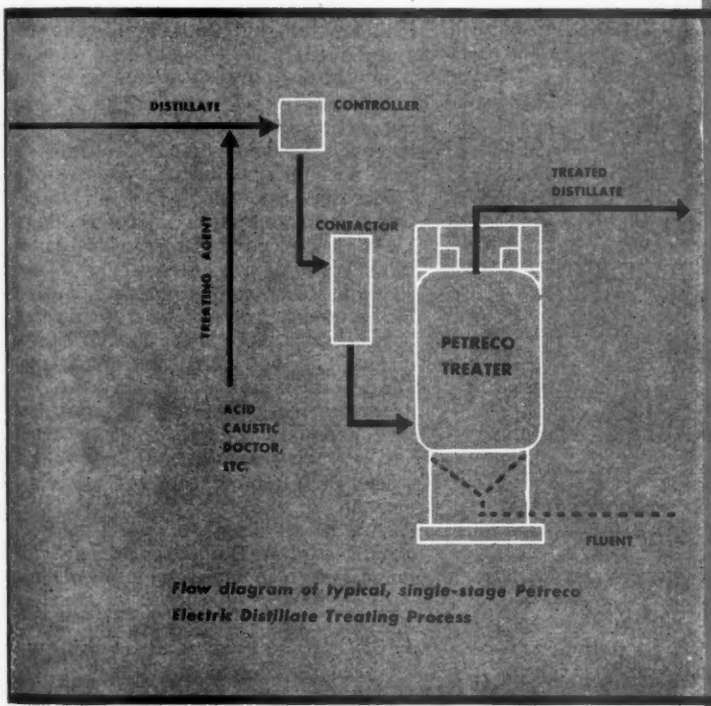

Flow diagram of typical, single-stage Petreco Electric Distillate Treating Process

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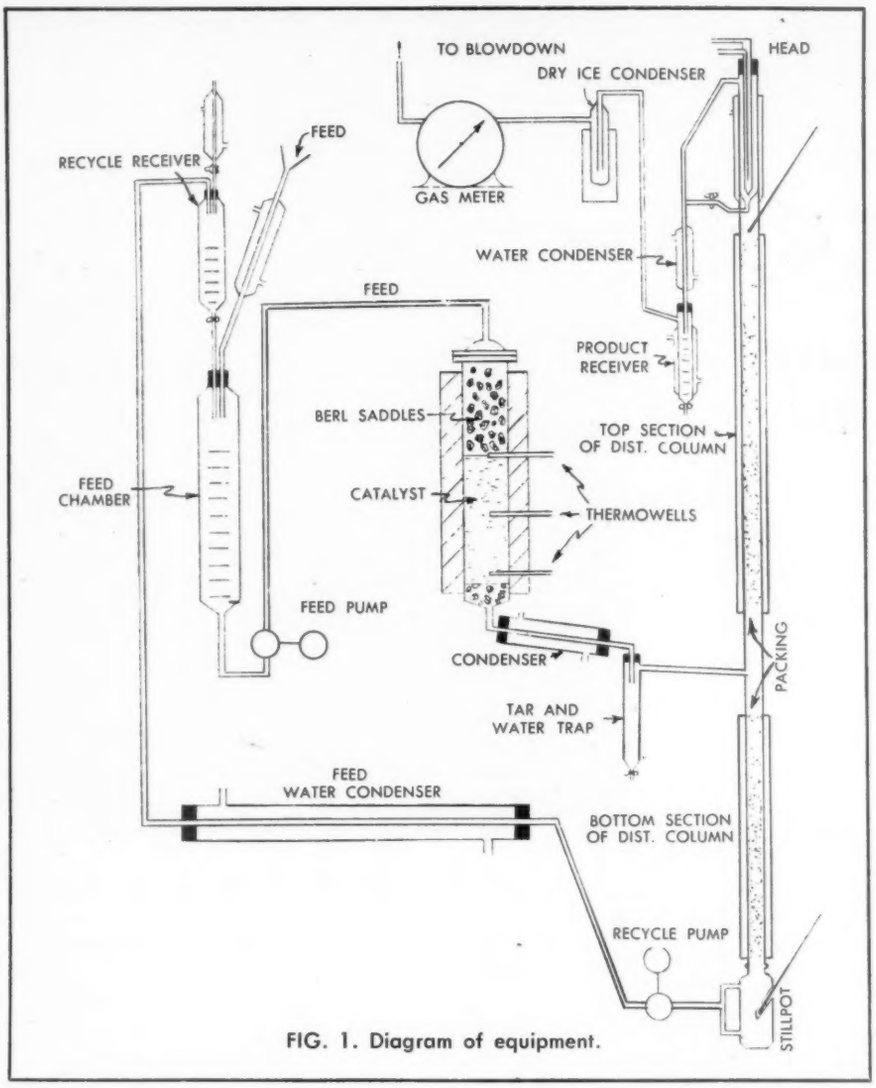

FIG. 1. Diagram of equipment.

Isomerization of Olefins

Pentene, hexene, heptene, octene, and ethylhexene were isomerized in continuous recycling system

LLOYD BERG*, H. A. SANER*, L. D. GUSTAFSON[1], W. J. LUKE[1], W. S. REVEAL[2]

IN the isomerization of low molecular weight hydrocarbons, the production of a given isomer is not difficult. It is relatively easy, for example, to produce isobutane in good yields by isomerizing n-butane. As the molecular weight increases and/or the configuration becomes more complex, the number of possible isomers increases rapidly. There are only four isomers of butene and six of pentene but there are 17 hexenes, 35 heptenes and at least 65 different octenes.

At any given temperature a definite thermodynamic equilibrium relationship exists among the several isomers of a given hydrocarbon and if sufficiently complete and accurate data are available, this equilibrium relationship may be calculated thermodynamically. This has been done for the hexenes and the results are presented in Table 1.[1] From these data it can be seen that at equilibrium the distribution is scattered over the majority of the isomers and at least a small quantity of each is present. The role of the catalyst is to aid in the establishment of this equilibrium and it is very doubtful that a catalyst could be found that would isomerize to one or two isomers exclusively.

From Table 1 the wide variation in boiling temperature of the several isomers of hexene can be noted. In general, the more branched the carbon chain structure, the lower will be the boiling point. Because of this difference in boiling temperatures, it is quite feasible to separate some of the isomers by rectification. But because of the small amount of any given isomer at equilibrium, only very low yields can be obtained by batchwise or once-through operation.

The solution to this difficulty appears to be to operate the isomerization reaction in conjunction with a continuous rectification column. If one or several of the isomers be separated continuously and the remainder recycled, most of the charge can be converted to a product having no resemblance to the thermodynamic equilibrium mixture. If the catalyst be active, the equilibrium will tend to be established, part of the product separated and removed, and the remainder recycled and equilibrium reestablished.

It was the purpose of this investigation to apply this procedure to the olefins pentene, hexene, heptene and octene. The isomerization of olefins has been accomplished using a wide variety of different catalysts.[4,6,7,8] Alumina activated with anhydrous hydrogen fluoride is very effective and was selected for this investigation.

It has been noted that this catalyst has a tendency to cause cracking and polymerization of olefins as well as isomerization. Kindschy[2] reported that alumina activated with anhydrous hydrogen fluoride when used as a catalyst for dealkylating alkyl benzenes acted also as an alkylation catalyst. For this reason close temperature control is important.

In general, chain branching tends to enhance octane number. Berg et al[5] found that the octane number of olefinic

TABLE 1. Thermodynamic equilibrium of the hexenes at 400 C.[1]

Isomer	B. P.—°C. (corrected for 637 mm.)	Equilibrium Mol Fraction %
Hexene-1	58.7	8.89
cis-Hexene-2	63.2	11.83
trans-Hexene-2	62.5	16.85
cis-Hexene-3	61.9	7.12
trans-Hexene-3	62.5	12.51
2-Methylpentene-1	56.7	22.85
3-Methylpentene-1	48.6	8.84
4-Methylpentene-1	48.8	4.83
2-Methylpentene-2	62.3	1.49
cis-3-Methylpentene-2	61.0	1.21
trans-3-Methylpentene-2	62.9	1.21
cis-4-Methylpentene-2	53.0	0.32
trans-4-Methylpentene-2	49.7	0.50
2-Ethylbutene-1	61.5	0.46
2,3-Dimethylbutene-1	50.6	0.44
3,3-Dimethylbutene-1	36.2	0.16
2,3-Dimethylbutene-2	68.2	0.44
		100.00

*Montana State College, Bozeman, Montana.
[1] Present Address: General Electric Company, Richland, Washington.
[2] Present Address: Shell Development Company, Emeryville, California.

EXCLUSIVE

gasolines was improved by one pass treatment over anhydrous hydrogen chloride activated alumina at 380-420 C. As the Fischer-Tropsch process tends towards the production of straight chain hydrocarbons, the process described herein should be applicable to hydrocarbons, from that source as well.

Equipment and Methods

The equipment used in this investigation is diagrammed in Fig. 1. The catalytic reactor consisted of a 24-in. length of three-inch standard mild steel pipe, well insulated and supplied with Nichrome resistance windings for electrical heat. Temperature was measured by iron-constantan thermocouples inserted in ⅛-in. standard pipe thermowells. The continuous column was constructed of three concentric Pyrex glass tubes, the innermost tube being 33 mm inside diameter and packed with ⅛-in. Fenske stainless steel helices. Calibration of the column with methylcyclohexane-toluene test mixture indicated the section above the feed plate comprised 30 theoretical plates and the section below the feed plate 14 theoretical plates. The design of Berg and Smith[3] was used for the adjustable reflux condenser at the column head. Feeding and recycling was accomplished by means of Merkle-Korff type bellows pumps.

The catalyst was prepared by treating ⅛-in. activated alumina tablets with anhydrous hydrogen fluoride as described by Kindschy.[2]

The catalyst was burned off after every 15-20 hr of use to remove the carbonaceous deposit which forms and tends to reduce its activity.

Some of the product was hydrogenated in order to simplify the identification of products. This decreases the number of possible isomers but still shows the degree of chain branching. The hydrogenations were carried out in a Parr 250 ml hydrogenation bomb using Universal Oil Products Company hydrogenation catalyst at 150 C (302 F) and 1400-1800 psi hydrogen pressure.

Discussion of Results

A large number of runs were made with each olefin studied. Twenty-two isomerization runs were made with hexene-1 with cycle times varying from three to eighteen hours. Similarly, several runs were carried out with pentene-1, heptene-1 and -2, octene-1 and ethylhexene. It was noted at once that the composition of the product from the column would vary with the reflux ratio employed. If the run was carried out using a very high reflux ratio, the product consisted of only the most volatile isomers but weight balances tended to be poor. The conditions settled upon and reported in Table 2 represent a compromise to obtain the most volatile product consistent with reasonably good weight balances. The analyses reported in Table 3 were made by infra-red spectrum methods.

The isomerization of pentene-1 was carried out in two different ways. In the first case, the product from the catalytic reactor was fed to the middle of the continuous column, the column overhead removed from the system at 5:1 reflux ratio as final product and the bottoms recycled to the reactor. This arrangement tends to convert the pentene-1 to the most volatile isomer, 3-methyl butene-1. If the catalyst employed is capable of converting any of the pentene-1 to 3-methyl-butene-1, then the amount appearing in the product would depend only on the efficiency of the column. In the second scheme, overhead was removed from the continuous column at 1:1 reflux ratio and recycled to the reactor while the column bottoms were taken off as product. Under such conditions, the least volatile isomer would be expected to appear in quantity. In Table 3 the great increase in the less volatile 2-methyl butene-2 and pentene-2 as well as the disappearance of the more volatile 2-methyl butene-1, 3-methyl butene-1 and pentene-1 is very apparent.

The value of this procedure as a method of enhancing octane number is shown in Table 3 where octane ratings of the hydrogenated products are listed. Had no isomerization taken place, the hydrogenated product would have been n-pentane and the octane number would be 62 instead of the 80 and 77 respectively found experimentally.

The difference in recycle operation as contrasted with once-through operation can best be appreciated by comparing the data listed in Table 2 for hexene-1 with the results obtained by Naragon for hexene-1.[7] This investigator showed that the highest yield of 2,3-dimethyl butane (diisopropyl), obtained by once-through operation was 12 per cent. By recycling, we obtained 16 per cent without difficulty, which is considerably higher than either the thermodynamic equilibrium reported by Naragon or that of 2,3-dimethylbutene-1 and -2 calculated by Berg et al.[1] On the other hand, Naragon reported n-hexane in amounts varying from 13 to 89 per cent of the product whereas we are able to eliminate almost entirely this higher boiling isomer. The octane number of the hydrogenated product was 76, which shows considerable enhancement over the 26 the product would have had if no isomerization occurred and it was 100 per cent n-hexane.

The absence of the most volatile hexene isomer, 3,3-dimethylbutene-1 (neohexene) is not surprising having been noted by Wachter[9] and Naragon[7] as being difficult to prepare and that even if formed, tends to revert to 2,3-dimethylbutenes. The hexene-1 used in this work was prepared by the dehydration of hexanol-1 with alumina.

Heptene isomerizations were carried

TABLE 2. Operating data and material balances from isomerization runs.

Charge	Hexene-1	Heptene	Pentene (overhead)	Pentene (bottoms)	Octene-1	Ethylhexene
Charge weight, grams:	460	100	100	100	300	300
Charge volume, ml.:	675	140	154	154	420	420
Time of run, minutes:	270	48	60	22	137	126
Feed rate, ml./min.:	16	12	15	17	16	16
Catalyst volume, ml.:	1500	1500	1500	1500	1500	1500
Average reactor temp., °C						
Upper (preheat) section:	306	290	295	270	325	320
Middle section:	385	373	375	350	375	375
Lower section:	396	371	375	363	374	371
Average column temp., °C at 640 mm.						
Head:	52.0	74.9	26.6	29.5	96	97.5
Section above feed plate:	58.5	84.0	30.0	33.0	102	113
Section below feed plate:	71.5	92.0	36.5	38.8	119	122
Stillpot:	74.0	102.2	43.0	35.0	127	125
Product weight, grams						
Liquid, column overhead:	421	91	95.6	96.5	292	293
Liquid, condensed in trap:	5	4	2.0	1.8	5	4
Non-condensible gases:	3	0.3	0.2	0.3	1	1
Total weight recovered, grams:	429	95.3	97.8	98.6	298	298
Total volume recovered, ml.:	625	137	150	152	418	418
Weight per cent recovery:	93.6	95.3	97.8	98.6	99.1	99.2
Volume per cent recovery:	92.7	97.9	97.0	98.5	99.5	99.5

TABLE 3. Product analyses and octane ratings.

		Pentene (Bottoms from column)
Pentene (Overhead from column)		
2- and 3-Methylbutene-1	16.0%	——
Pentene-1	26.0	——
Isopentane	2.9	——
2-Methylbutene-2	21.5	33.7
Pentene-2	32.1	62.2
n-Pentane	1.5	4.1
Octane No., Hydrogenated Product ASTM, Research Method	80.0	77.0
Hexene product after hydrogenation		
2,2-Dimethylbutane	0.6%	
2,3-Dimethylbutane	16.0	
3-Methylpentene	18.6	
2-Methylpentane	63.2	
n-Hexane	1.6	
Octane No. -ASTM, Motor Method	76	
Heptene product after hydrogenation		
2,3-Dimethylpentane	13.3%	
2,3-Dimethylpentane	20.8	
3-Methylhexane	28.6	
2-Methylhexane	33.4	
n-Heptane	3.9	
Octane No. -ASTM, Research Method	60.6	
Octene-1 Product after hydrogenation		
Octane No. -ASTM, Motor Method	70.4	
Ethylhexene product after hydrogenation		
Octane No. -ASTM, Motor Method	71.3	

out with a mixture of heptene-1 and -2 obtained by dehydration of heptanol-2 over alumina. The data in Table 3 show that almost complete conversion to branched chain isomers is accomplished for heptene just as it was for hexene, by taking product off as overhead and recycling the column bottoms. Octane number improvement of the hydrogenated product is 60 units, n-heptane having a rating of zero.

The isomerization of octene was carried out with two different charge stocks. One was octene-1 available commercially and the other was a mixture of the ethylhexenes obtained by dehydrating 2-ethylhexanol with alumina. Both were taken off overhead with the column bottoms being recycled. Even the hydrogenated product was so complicated that significant analyses could not be made. Octane number determinations on the hydrogenated products were 70 and 71 respectively indicating similar composition. This may be compared with –17 for n-octane and 35 for 3-methylheptane, the products resulting in the absence of isomerization reaction.

These results indicate that limitations imposed by once-through operation on the conversion of straight chain olefins to branched chain can largely be circumvented by carrying out the isomerization reaction in conjunction with a continuous column and recycle of the unwanted isomers, and that almost complete conversion to branched-chain isomers can thus be accomplished.

Acknowledgment

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* * *

Plant Aids

Hand Pipe Cleaner

W. B. BOWEN*¶

A jeep, tractor, or other vehicle with power take off is required. Come off the power take off shaft with a universal joint, to this attach a shaft 36 in. long made of 1-in. pipe or ¾-in. rod with another universal on its end; on this universal weld a swaged fitting that will just slip on over the pipe to be cleaned at its big end, cut a hole in this collar and weld a bolt nut directly over hole, screw a bolt into the nut for a set screw.

Build two pipe rolling dollies of two large ball bearings each welded to a heavy steel plate ⅜ by 18 in. by 8 in. weld these on two horses made of 2-in. pipe about 24 in. high, place the horses about 15 ft apart, tie them together by welding a 3-in. I beam on top of the dolly plates so that its top will be about 2 in. from the pipe resting in the dolly rollers, this beam should be at least 20 ft long. Cut a hole in the dolly plates just at the edge of the pipe resting in the dollies and on the side toward which the pipe will roll put long bolts in these holes to prevent pipe from climbing out of rollers.

Use tool over I beam like a wood lathe, any kind of tool may be used such as files, wire brushes, chisels, etc., or cutter knives from an old cleaning machine may be used. Rotate pipe at any desired speed, this can be determined by experience.

If desired the pipe may be painted with brush or rag while rotating slowly.

The vehicle may be backed up or driven forward to clean long joints of pipe.

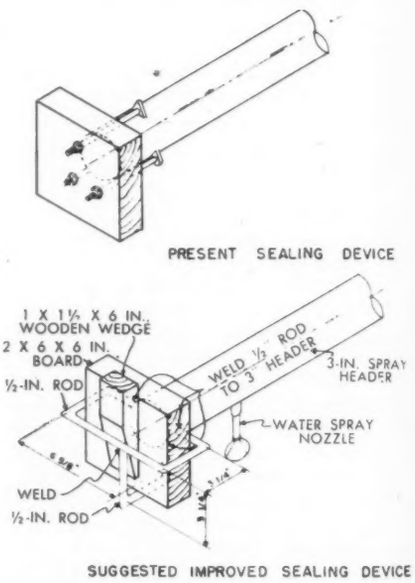
[15]Class D, third prize, NGAA — Panhandle-Plains Regional Meeting, Amarillo, Tuesday, November 20, 1951.

*¶Panoma Corporation, field foreman, Guymon, Oklahoma.

Cooling Tower Cleaning Aid[1]

JIM BARTON*

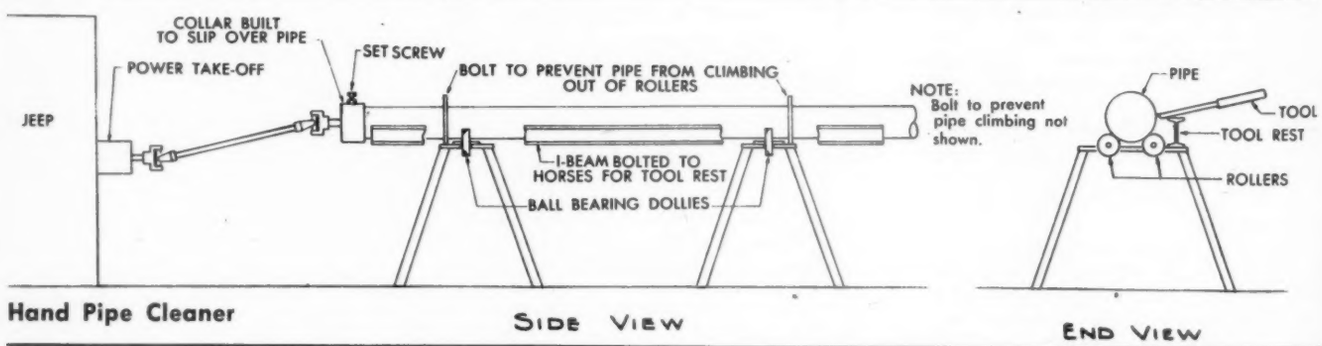
The conventional sealing devices for the end of spray header piping are screwed caps or wooden blocks bolted to lugs affixed to the spray header. The suggested sealing device consists of a basket receptacle fabricated from ½-in. rod, the box-like receptacle being welded to the end of the pipe, and of sufficient size to contain a square 2-in. thick wooden block of proper diameter to cover the open end of the spray pipe. The block is to fit loosely enough in the container to permit a wooden wedge to be inserted between the block and the ½-in. rod at the face of the block. A sharp tap of the wedge forces the block sufficiently tight against the pipe opening to permit a near water-tight seal. To remove the block the wedge is knocked out and the loose block lifted out of the housing by hand. No movable metal parts are featured in the device, hence corrosion is no problem. No tools other than a hammer or other striking tool needed to insert or remove seal.



Wooden block sealing device for end of cooling tower spray header to facilitate cleaning

[1]Class A, first prize, NGAA—Panhandle-Plains Regional Meeting, Amarillo, Tuesday, November 20, 1951.

*Phillips Petroleum Company, maintenance superintendent, Box 358, Phillips, Texas.



Hand Pipe Cleaner

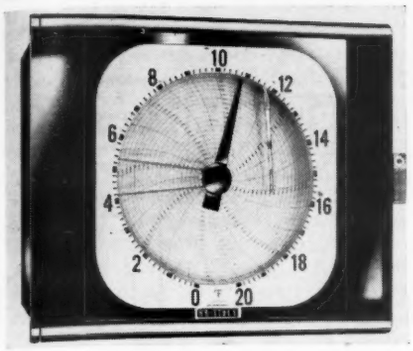


FIG. 1. Round-chart Dynamaster.

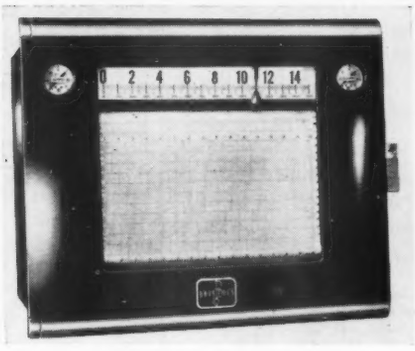


FIG. 2. Strip-chart Dynamaster with air-operated controls.

Trends in Refinery INSTRUMENTATION

PART 6—Bristol Dynamaster Potentiometers and Bridges

CHARLES F. JOHNSON, JR.*

ONE of the most important problems faced by the designer of process equipment and by instrument engineers is the proper specification of recording and controlling instruments for industrial equipment. In selecting these devices, the engineer will wish to rely on types permitting the widest range of adaptability in use, a minimum stocking of component parts, and the maximum reliability in operation, coupled with the highest possible degree of freedom from external influences. These points have special force when a decision is being made as to instruments of the electronic potentiometer or bridge types, since, generally speaking, wider differences exist between currently-offered brands of such equipment than are found between brands in most other classes of measuring and controlling apparatus.

The purpose of this article is to give the process designer and operating supervisor a clear, factual picture of the Bristol Dynamaster line of electronic potentiometers and bridges, in relation to the points just mentioned. The discussion relates particularly to the selection, installation, maintenance, and periodic checking and general care of the various models manufactured by The Bristol Company, Waterbury, Connecticut.

Selection

The Bristol Dynamaster instruments are of the automatic, self-balancing, null-type, designed to measure electrical resistance, capacitance, inductance, current, or voltage. They can be easily adapted to measure, record, or provide process control from any variable that can be converted into these electrical quantities. Electronic principles are used in the form of a high-gain, vacuum-tube amplifier arranged to detect the voltage unbalance in the potentiometer or bridge circuit and to amplify that voltage sufficiently to operate a rebalancing motor. Because the process of detection and amplification is continuous, the Dynamaster is a continuous-balance instrument. Use of the electronic detector-amplifier eliminates the galvanometer and intermittently acting detecting mechanisms found in the older mechanical self-balancing type of instruments. There is, as a result, no delay between the occurrence of an unbalance and the beginning of the corresponding corrective action.

An important feature of the Dynamaster in all the various models is the standard "building-block' construction whereby the same basic components are used in both the potentiometer and the bridge types of circuits. Not only does this make for ease of checking and replacement, but also it permits carrying a relatively smaller service stock from which effective, uninterrupted operation can be maintained for a group of instruments. The amplifier units of both the bridge and the potentiometer Dynamasters are identical and fully interchangeable with mounting and connection arrangements designed for rapid and easy replacement. Vacuum tubes used are non-selected, unmatched, and of types that can be obtained at any radio supply store.

The unit construction of Bristol Dynamasters reduces greatly the difficulties commonly experienced in attempting to convert instruments from one use or kind of application to another in the field. This is of particular interest to users of many instruments who are obviously concerned, and rightly so, with reducing the number of different types of equipment required in their plants and with keeping to a reasonable minimum the required stock of spare parts and replacement components. The "unitized" design of the Bristol Dynamaster makes it a relatively simple matter, with a few basic service tools and instruments, to convert a potentiometer instrument to a bridge, and vice versa. While this procedure is not one that would ordinarily be attempted by the instrument user having only a limited equipment or experience at his command, it is definitely one which could be and, as a matter of fact, has been followed through very successfully by users who have established instrument supervision and service programs.

The selection of a potentiometer or bridge type of instrument thus depends not only on considerations as to the kind of service to be performed and the accuracy requirements to be met, but also on the adaptability of the instrument to other applications or to laboratory use, if required. Furthermore, it is wise to choose an instrument which will have as high a degree of freedom as possible from external influences, such as vibration, ambient-temperature fluctuations, and stray electric or magnetic fields. The accessibility of all major components should be checked from the standpoint of maintenance and routine testing. In electrical or electronic instruments, it is particularly important to see whether there is provision for making simple point-to-point tests of the operation of basic components.

With the Dynamaster series, all these factors have been incorporated as cardinal features of the design, as is fully explained in the sections covering installation and maintenance.

Dynamaster Bridge

The alternating-current bridge is one of the two basic models of the Dynamaster. It is a high-speed self-balancing instrument designed to measure resistance, inductance, or capacitance with a high degree of accuracy and sensitivity. It can be used as a resistance thermometer, strain gage, conductivity meter, or in any other manner in combination with a sensing element whose resistance, inductance, or capacitance changes as a function of the measured variable. The basic components of the bridge model consist of:

1. An electrical bridge-circuit, usually supplied with low-voltage alternating current. This includes the sensing elements, balancing slide-wire, and fixed resistors,
2. An input transformer (included

*Application engineer, The Bristol Company, Waterbury 20, Connecticut.

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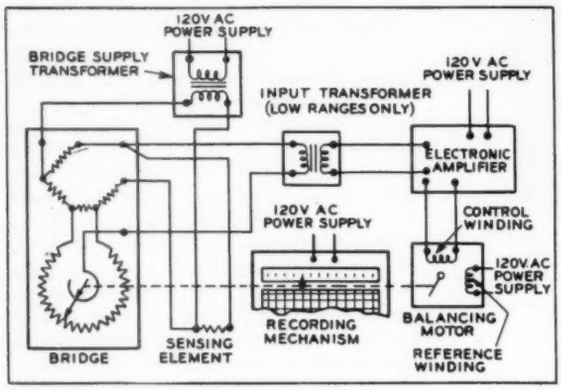


FIG. 3. Schematic diagram of bridge instrument.

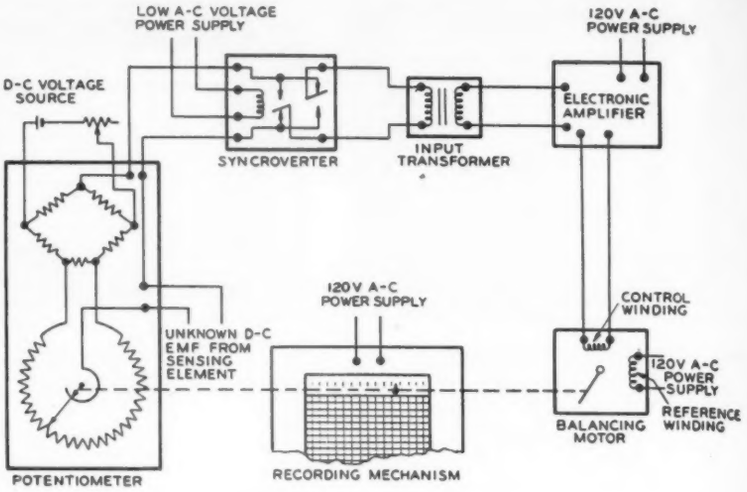


FIG. 4. Schematic diagram of Dynamaster potentiometer instrument.

only on low-range instruments to step up the a-c unbalance voltage — frequently called "error-signal" — before it is applied to the amplifier),

3. A four-tube electronic amplifier for increasing the a-c error-signal to a power level sufficient to operate the control winding of the balancing motor,
4. A two-phase bridge-balancing-motor which drives the slide-wire contact to rebalance the bridge, and simultaneously positions an indicator and recording pen to the corresponding value of the measured variable on the instrument scale and chart.

Although the Dynamaster bridge is also built in a model for d-c operation, most applications make it possible to use the customary 60-cycle power lines as source of power for the bridge circuit. Use of alternating current eliminates the batteries or rectifiers required by direct-current bridges and the d-c to a-c converter that would be needed between the bridge and the electronic amplifier. The use of d-c to a-c conversion also commonly requires an input transformer between the converter and the amplifier. With a-c supply to the bridge, this input transformer is eliminated, except on instruments for very low-range measurements. The use of an a-c power supply for the bridge where possible therefore definitely reduces the number of components of the instrument system.

Operation of the Dynamaster bridge is as follows. A change in the condition affecting the sensing element, e.g., change in temperature in the medium surrounding a resistance thermometer bulb, creates an unbalance condition in the bridge-circuit of which the sensing element forms one leg. (See Fig. 3.) This a-c voltage unbalance (error-signal) is stepped up by the electronic amplifier to a power level sufficient to energize the control field of the balancing motor and thereby cause rotation in a direction to achieve a rebalance of the bridge. The reference winding of the two-phase balancing motor is connected to the a-c power supply, and the direction the motor rotates depends on the phase relation between the reference voltage and the amplifier error-signal applied to the control winding. This phase relation is a leading or lagging one according as the measured variable is increasing or decreasing. Since the instrument system is entirely electrical, with no intermittently-acting elements interposed, the operation of rebalancing is continuous, and starts immediately upon the occurrence of the slightest bridge-unbalance.

The Dynamaster self-balancing bridge is adaptable, with only minor modifications, to a wide variety of measurements. It may be used with many industrial-type pickup units that produce an impedance change, which is a function of the change in the measured variable. The resistance-type thermometer, for example, provides a highly accurate and reliable method of measuring temperature. Various types of bulbs are available, the usual one consisting of a coil of fine wire enclosed in suitable metallic protecting sheath. For certain metals or alloys, the resistance change with temperature is sufficiently large and reproducible to permit highly accurate temperature measurement. Standard bulbs suitable for practically all industrial applications are provided from stock of the company, matched to the range and accuracy of the individual bridges for which they are intended. The Dynamaster bridge is an ideal instrument for recording such measurements from one or more thermometer bulbs. Other bulbs, for special applications, are made to order. Standard resistance thermometers are offered for full-scale ranges as narrow as 5 F, although even narrower spans can be made for certain applications.

Another increasingly popular use of the Dynamaster bridge is with sensing elements of the strain-gage variety, for stress analyses in research laboratories and for measuring variables such as pressure, load, weight, strain, and torque on industrial process equipment. As the resistance changes occurring in strain-gage elements are relatively small, a step-up transformer is provided in the Dynamaster recorder, between the bridge-circuit and the electronic amplifier. Manually adjustable resistors are included in the circuits to allow the instrument to be matched to the individual strain gage being used, and to correct for possible drift of gage characteristics and for adjustment of lead length between gage and recorder.

The Dynamaster bridge is readily adaptable to use with inductance-type, position-sensing elements, or pickup units. In the usual element, an iron armature is positioned within a solenoid by a measuring unit developing a mechanical effect such as linear movement or torque. Variations of the inductance of the wire coil are measured and recorded by the Dynamaster. Several forms of inductance pickup units are commercially available.

When connected to an electrode unit of known-dimensions or "cell-constant," the Dynamaster bridge may be calibrated in terms of the electrical conductivity of a specified type of electrolytic solution. For such applications, it is generally necessary to introduce corrections in the measurements to offset the variation of conductivity caused by temperature changes in the solution. Circuitry is available whereby this correction may be made by means of a manually-positioned knob controlling an adjustable resistor in the bridge-circuit, or for making it automatically by means of a temperature-sensitive resistance element submerged in the liquid and connected to the bridge network. Dynamaster conductivity meters are being used for continuous supervision of the quality of distilled water, boiler feed, control of losses in the effluents from various chemical processes, and in sundry other ways.

On telemetering applications, there are two principal ways in which the Dynamaster bridge is used: The first system provides for operating the recorder

from measuring units in which the position of a contact on a slide-wire is a function of the measured variable. Continuous telemetering and totalizing are obtainable with this method over three-conductor circuits not exceeding approximately two miles in length. The second type of Dynamaster telemetering is available in connection with Bristol's Metameter Time-Impulse System. This method can be used over unlimited distances, on private two-wire lines, on telephone lines, carrier-current channels, and radio channels. Either of the Dynamaster telemetering systems can be used to transmit and totalize pressure, flow, liquid-level, temperature, position, electrical quantities, and other industrial variables.

Dynamaster Potentiometers

A high-speed self-balancing d-c potentiometer is the second of the two basic models of the Dynamaster. This instrument, fully as versatile in its own field as the Dynamaster bridge, is available for the rapid and accurate measurement of direct electromotive force (emf) of unknown value by comparing it with an emf of known value. The comparison is effected automatically and continuously, so that operation is fully comparable with the action of the fast Dynamaster bridge. However, the potentiometer system includes among its standard components two units not ordinarily present in the bridge, namely, the Syncroverter, a synchronous switching device for changing the d-c unbalance of the potentiometer to an a-c suitable for electronic amplification, and, secondly, an input or step-up transformer between the converter and the amplifier. (See Fig. 4.)

The amplifier unit, which is the same in all respects as used in the Dynamaster bridge, operates to supply power to the control winding of the rebalancing motor in the manner already explained for the bridge instrument. On very low ranges a one-tube preamplifier is interposed between the input transformer and the standard amplifier.

Process designers and instrument engineers attach considerable importance to the fact that in the Dynamaster potentiometer the input transformer, amplifier, balancing motor, and the complete recording mechanism are identical with those used in the Dynamaster bridge. This identity of parts between the two basic models simplifies the stocking of replacement units where both types of instruments are used.

The operation of the Dynamaster potentiometer may be summarized as follows. The primary sensing element, i.e., thermocouple, tachometer generator, pH amplifier, radiation thickness gage, photoelectric cell or other source of direct emf, is connected into one branch of the potentiometer circuit. Whenever a change occurs in the emf from this element, the potentiometer circuit is thrown out of balance, thereby producing a d-c error-signal which is immediately translated by the Syncroverter into an a-c error-signal. This alternating emf is then stepped up by the input transformer and fed to the electronic amplifier for development of corresponding power to drive the rebalancing motor. As in the bridge-type instrument, the rebalancing action is continuous and takes place immediately upon the slightest change in the output supplied by the primary sensing element.

The direction of the rebalancing action of the Dynamaster potentiometer depends on the phase relation between the a-c error-signal from the Syncroverter unit and the a-c power-line supply voltage fed into the reference winding of the two-phase balancing motor. This phase relation, in turn, depends on the direction of unbalance in the potentiometer circuit.

Dynamaster potentiometers are available for recording measurements from primary sensing elements which produce direct voltages or currents over a wide range of magnitudes, all the way from elements that yield outputs of volts or many millivolts, to elements whose total output never exceeds a few microvolts. The bimetallic thermocouple, for example, is a favorite means of industrial temperature measurement in the range from —3000 to +3000 F. Bristol offers a wide variety of standard thermocouples, extension wire, protection tubes, and fixtures for use in conjunction with its Dynamaster potentiometers. In addition, facilities are such as to permit the design and manufacture of almost any type of special thermocouple.

The high-speed Dynamaster potentiometer is ideal for making temperature measurements by the total radiation method in the range 900 F to 5000 F, and a special "Pyrovisor" radiation pickup head is manufactured for this type of service. The combination of the pyrovisor unit and the Dynamaster recorder provides a pyrometer system having the unusually short response time of 1 second for 90 per cent of an instantaneously applied temperature change. The combination is particularly good for recording the temperatures of moving objects, such as hot-metal sheets and billets in rolling mills, or other objects which may be subject to rapid fluctuations of temperature or fast movement across the line of sight.

When coupled with a suitable combination of pH electrodes and amplifier, the Dynamaster potentiometer provides an excellent means for recording or controlling the acidity or alkalinity of solutions. Here again, the customer has the advantage of dealing with a single source of supply, in that a complete line of pH electrodes, amplifiers, and accessories is available from the manufacturer of the recorder.

The Dynamaster may be readily applied to the measurement of d-c magneto output and thus to the recording of speed in terms of revolutions per minute, feet per minute, or other values, of the shaft or rotating equipment to which the magneto is coupled.

The measurement and totalization of electric power may be performed ideally through the combination of the Dynamaster potentiometer with the thermal wattmeter, the "Thermoverter." The thermal wattmeter is a conversion device for measuring a-c power in terms of d-c millivolts. The high speed of response of both the thermoverter and the Dynamaster provides a combination which can record extremely rapid power fluctuations.

Recording and Controlling

The Dynamaster instrument, as either bridge or potentiometer, is offered with either the round-chart or the strip-chart style of recording system and with or without a variety of auxiliary features, such as pneumatic or electric control equipment, alarm contacts, program control mechanism, and others.

The round- and strip-chart versions of the instrument are illustrated in Figs. 1 and 2. From these, it will be noted that the round-chart model affords, in addition to the recording feature, a circular-shaped indicator scale with large, clearly visible rotating pointer, whereas the strip-chart model has a shorter rectilinear-type indication scale and a smaller pointer. Where measurements must be read at some distance from the instrument board, the round-chart model thus has the advantage of greater visibility. Perhaps its chief limitation is that it is not readily adaptable to the making of measurements with more than one primary sensing element, as can be so readily done with the Dynamaster strip-chart instrument. Also, it must be recognized that some users prefer, for various reasons, the strip-chart method of recording, in which the time-graduations are uniformly spaced across the chart.

The Dynamaster strip-chart model is available for use with from 1 to 16 separate measuring elements. Where more than one element is involved, the measuring system of the recorder is periodically switched from one point to the next by a multiple switching-mechanism driven by a synchronous motor. The switching device is mechanically coupled to the recorder printing-wheel, which is actuated so as to place a small dot of ink on the chart at a point corresponding to the value of the measured variable as reported by each of the individual measuring elements intermittently throughout the switching cycle. The record produced by the multiple-point recorder is thus not a continuous line, but a series of dots. In the direction of the time axis, the spacing between consecutive dots of the record corresponding to one of the measuring elements will depend on the relation between the time required for a complete cycle of the switching and the speed of chart-travel. Many chart speeds are offered, ranging from ¾ in. per hour to 120 in. per minute to suit the requirements of a wide variety of applications. Chart speeds can be readily changed over a limited range merely by change of the chart-drive gearing. For more extreme changes, it is necessary also to replace the chart-drive motor with another having a different rotational speed.

The speed of pen-travel of the Dynamaster instrument is such as to take full advantage of the rapid rebalancing characteristic of the continuous electronic system. Dynamasters are furnished with speeds of 7 sec, 3 sec, and 2/3 sec for

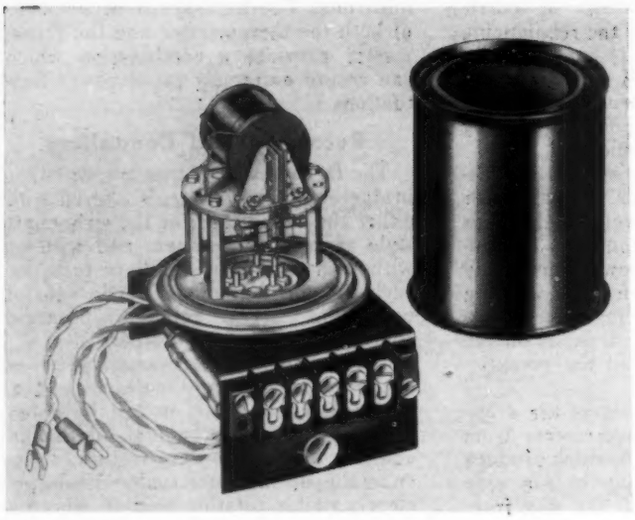


FIG. 5. Bristol's Syncroverter.

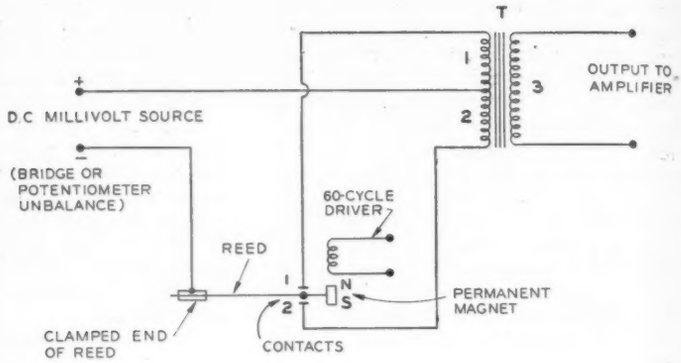


FIG. 6. Single-pole inverter in self-balancing instrument system.

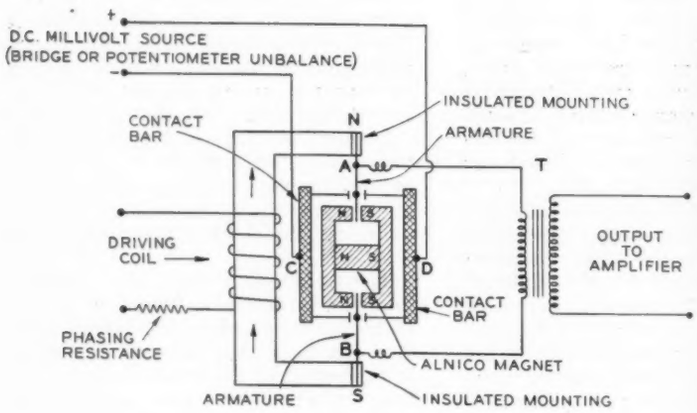


FIG. 7. Syncroverter in the Dynamaster instrument system.

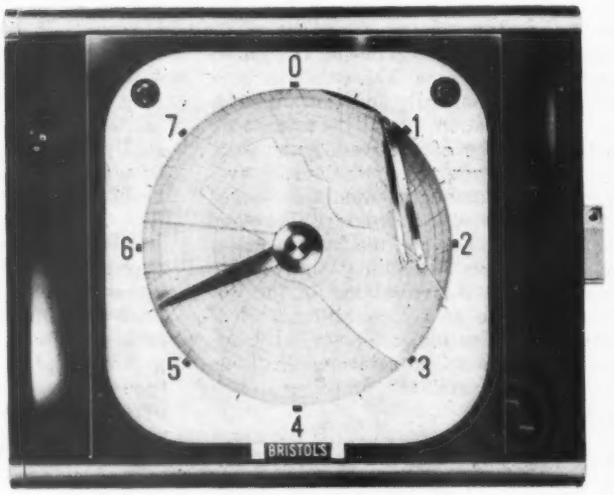


FIG. 8. Dynamaster program controller.

full-scale pen-travel, pen motion being steady at a practically fixed rate of speed, regardless of the extent of the unbalance. The 7-sec pen-travel recorder was designed to be fast enough to follow the changes in output experienced with most kinds of sensing elements. Generally speaking, the slowest pen-travel speed adequate for the application should be selected, since an increased mechanical and electrical burden is placed on the instrument at the higher operating rates.

Multiple-record Dynamasters are available for recording measurements from 2 to 16 separate measuring elements. Three types of records may be had as standard with these multi-point instruments:

On instruments having 2 to 6 points:

1. Contrasting colored dots printed from ink-saturated felt pads.
2. Contrasting colored dots and numerals printed from ink-saturated felt pads.

On instruments having 2 to 16 points:

3. Purple dots and numerals printed from ink-saturated pad.

The multiple-recording mechanism itself is designed so as to have a minimum of parts and adjustments. The rotary switch is mounted at the rear of the swinging panel and is easily accessible for inspection and service. The Dynamaster bridge uses a three-pole switch in a manner which minimizes the effective switch contact resistance, while the Dynamaster potentiometer uses a two-pole switch so as to connect or disconnect both sides of the line from the sensing element. It is impossible for the print-wheel to get out of step with the rotary switch, because of mechanical interlocking through a gear train. The switch may therefore be positioned manually, if desired, without loss of synchronism between switch and print-wheel.

Standard printing intervals for the multiple-record Dynamaster are 8 sec, 15 sec, or 30 sec of elapsed time between successive recordings from any given measuring element. In selecting the chart speeds for these multiple-record instruments, it is necessary, of course, to consider the possibility of overprinting of the record, as too slow a chart speed will produce markings illegible due to overlapping of the successive prints. Generally speaking, multi-colored dot printing (available in from 2 to 6-point recorders) is recommended to avoid difficulties of this variety. It is much easier to distinguish between different colors than to try to read overlapping numbers which are printed in a single color. Where single-colored numbered records must be used (necessary for 8 to 16 points), however, the slowest non-overlapping chart-speed should be estimated from (a) the number of points, (b) the time between the printing of successive records from the same sensing element (i.e., the printing interval), and (c) the fact that each numbered printing requires about 1/16-in. of chart space. A convenient formula for use in calculating the minimum chart speed in inches per hour is the following:

$$\text{Inches per hour} = \frac{225}{\text{No. of points} \times \text{printing interval, secs.}}$$

Where overprinting is due to the measurements from two or more sensing elements approximately coinciding in

value, the elements concerned should be so connected to the rotary switch as to be as far apart in time as possible. For example, if the records from two sensing elements are of about the same value, and a six-point recorder is being used, the element lead wires for these two records should be connected to points Nos. 1 and 4 (or Nos. 2 and 5, or 3 and 6), as such an arrangement will give the maximum time for chart movement between successive printing of the adjacent records. When it is desired to eliminate entirely the overprinting caused by coincidence of records from two or more elements, the minimum chart-speed required may be computed from the formula:

$$\text{Inches per hour} = \frac{225}{\text{Printing intervals, secs.}}$$

On most Dynamaster potentiometer instruments, the balancing voltage of the potentiometer measuring circuit is derived from a dry cell, and is periodically compared with the voltage of a standard cell. A rheostat connected in the potentiometer circuit is automatically repositioned so as to compensate for changes in the dry-cell voltage. For single-record potentiometers, standardization occurs automatically once every ten minutes and lasts for approximately six seconds, although on some instruments using faster chart-drives, the standardization occurs more frequently and lasts a correspondingly shorter time. Multipoint Dynamasters are standardized automatically at the conclusion of each group of 48 printing operations, and the standardization is synchronized so as not to interfere with normal printing. On Dynamaster bridges, power for the measuring circuit is taken through a transformer from the alternating-current power lines. No battery is used and no standardizing mechanism is required.

A convenient feature of Dynamaster potentiometers is the provision of a push-button switch on the instrument panel, for use in manually standardizing when desired. This has been found particularly valuable when several dynamasters are being used together on a continuous test or other operation, because it permits all instruments to be standardized simultaneously.

An excellent substitute for the automatic standardizing apparatus and dry-cell of potentiometers is a constant-voltage device now available for Dynamaster instruments. This is a unit which operates from the a-c power supply and furnishes a constant d-c potential to the balancing circuit. The constant-voltage device completely eliminates the need for a dry-cell and standardizing mechanism and represents a notable simplification of the instrument.

Syncroverter

The Bristol Syncroverter, a component of all Dynamaster potentiometers, is a synchronous electrical switch of the vibrating-reed class, designed primarily for operation as an "inverter" — i.e., as a means for changing direct potentials into alternating potentials. It is a unique development in the field of d-c to a-c conversion devices, incorporating operational characteristics not available with the usual types of vibrating converters. Two of its most significant features are its double-pole, double-throw mode of operation (two reeds operated in precise synchronism) and the arrangement whereby the permanent magnet polarizing means is not carried by the reeds, but rather is mounted in a fixed position in the magnetic circuit. The illustration, Fig. 5, shows the actual production form of the Syncroverter.

The two points just mentioned are responsible for several important advantages to be gained through the use of this device for converting small direct emf's into alternating. The double-pole, double-throw principle of operation, coupled with the very large acceleration impressed upon the reeds, permits the Syncroverter to be made with a highly symmetrical operating characteristic. Attainment of precise symmetry of switching is a real advantage in that it makes possible the design of a simple amplifier network having a high discrimination against any stray potentials of power-line frequency which may be picked up in the circuit of the measuring element. A-c pickup having the same frequency as that of the current through the driving coil of the Syncroverter is almost entirely converted into harmonics of even order superimposed on a d-c. The d-c component is isolated from the amplifier by the input transformer, and the harmonics are filtered out by the circuit arrangements of the Dynamaster amplifier. The combination of Syncroverter, input transformer, and standard Dynamaster amplifier has in fact been engineered to reject not less than 99.95 per cent of the total effective value of components arising from stray potentials of power-line frequency picked up by the measuring element and lead wires. It is very interesting to note that this is performed without the use of auxiliary filtering equipment such as is necessary to achieve the same result when a single-pole, semi-resonant type of vibrator is used as the conversion element.

For some kinds of inverters, the phase relationships of the switching action to the line current, which are of fundamental importance to the correct operation of the rebalancing system of the recorder, can be seriously upset by mechanical shock or vibration. This is caused by a low force-to-mass ratio (acceleration) of the moving element consisting of reed and permanent magnet polarizing means commonly mounted on the reed, together with the fact that such devices are quite commonly designed to have a point of strong mechanical resonance in the vicinity of the frequency on which they are operated. The Syncroverter avoids both these objectionable characteristics by impressing a very high rate of acceleration upon the reed system (an acceleration more than a thousand times as large as that which is commonly provided in vibrators for instrument service), and by being designed to have no significant mechanical resonance effects anywhere in the vicinity of the operating frequency, up to frequencies as high as 2000 cps.

The schematic diagrams, Figs. 6 and 7, allow making a comparison between the circuit connections used for the Syncroverter and those used for a single-pole vibrator, in a recording potentiometer system. It will be noted that the unit, because of its double-pole reversing-switch action, is connected to a single winding in the input transformer, whereas the single-pole type of converter must necessarily be fed into a center-tapped primary winding. Symmetry of output of the single-pole device may thus be affected not only by phase shifts due to mechanical resonance effects, shock, and thermal variations, but also may be further reduced by lack of good match between the two halves of the center-tapped primary of the input transformer. The double-pole Syncroverter design assists very materially in cancelling thermal effects arising at the switching contacts— effects which are necessarily additive in the single-pole type. * * *

Part 7 will be published soon.

Refining Capacity Boosted in 1952, API Reports

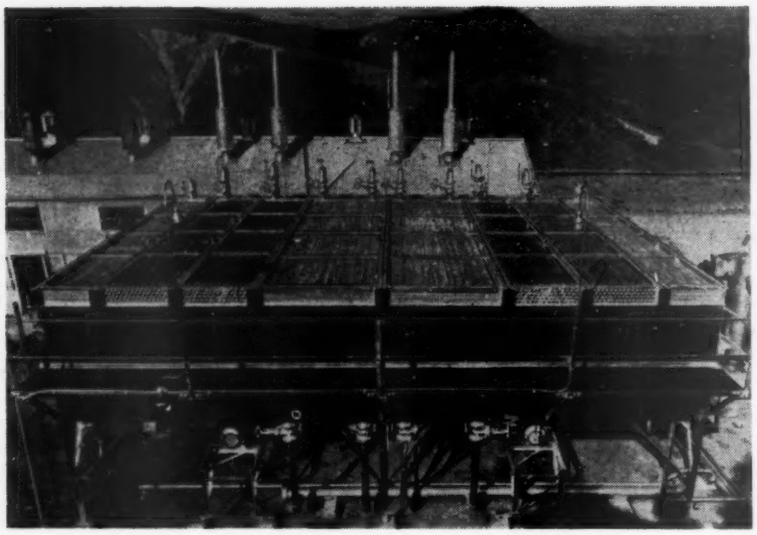
To assure the American people a continuing flow of petroleum products, the U. S. oil industry boosted its operable refining capacity by more than 350,000 bbl per day in 1952, the American Petroleum Institute has reported.

A survey by the Institute's statistical department in the middle of December showed that the industry expects to have an operable refining capacity of 7,585,100 bbl per day by December 31—an increase of 356,000 bbl, or five per cent over the 1951 close of 7,228,500 bbl.

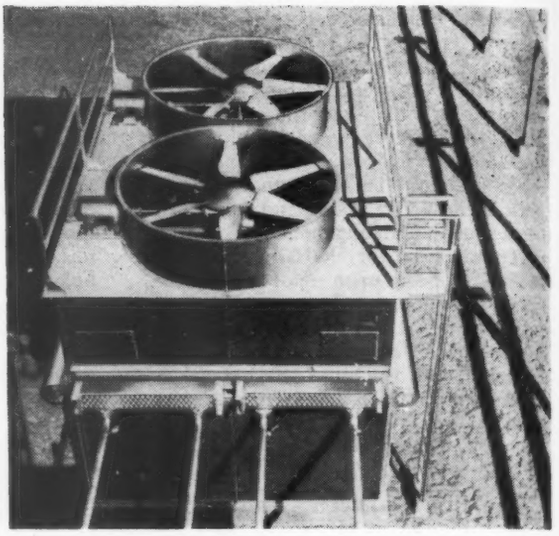
The survey, which also covered estimates for the first three-quarters of 1953, forecasted a further increase of 157,700 bbl per day by next September 30. This will raise the over-all total of operable refining capacity to 7,742,800 bbl per day, the API report noted.

Operable refining capacity is an index of the industry's ability to process crude oil with existing equipment and convert it into useful products and compounds. The statistical department noted that the survey totals do not include 28,000 bbl daily, which were in need of major repairs and shut down as of last September 30, or 93,000 bbl which, while operable, also were shut down because they were believed to be in the high cost marginal group.

The department said the survey figures for 1952 included about 293,000 bbl per day in which the crude oil is charged direct to cracking units.



Forced-draft air-cooled unit with 3 sets of coil sections. Narrow sections at either end (⅝ in. tubes) cool soft water for compressor jacket and lube oil coolers. Wide sections in center cool engine jacket water. The other 4 sections (1 in. tubes) cool first and second stage gas.



Induced-draft air-cooled unit cools fluids used for sweetening and dehydrating gas. One section is stripper overhead condenser to cool H_2S and CO_2 gases and to condense stripping steam. Other section is dehydration plant gas-cooler.

Economics of the Air-Cooled Heat Exchanger

An important development for process cooling

J. C. CHASE* and H. E. DEGLER*

Where high level heat removal is desired (25 to 50 deg above the maximum expected air temperature), the air-cooled heat exchanger has particular advantages especially if water is expensive or contaminated. Other advantages include the elimination of most water problems such as its availability, chemical treatment, corrosion, spray nuisance, freezing hazard, and fouling; as well as reduction of costs for operation and maintenance.

As the temperature of the fluid-to-be-cooled rises, the cost of the dry-air cooling unit decreases relative to that of a cooling tower for the same service. The economic selection of industrial cooling equipment should be based upon comprehensive specifications and complete cost information; a meticulous evaluation of types is recommended.

Included is a discussion of the advantages of air as a direct cooling medium, types of air-cooled heat exchangers, development and application, design air temperatures, power requirements, and pertinent correlated items.

The increasing need for cooling equipment requires that the choice be based upon a careful study of the applicable present-day types. The following factors are relevant: Availability of water supply, fluid temperatures, performance requirements, location, design features, installed price, operating costs, ease of maintenance, and life expectancy.

A recent major development of industrial cooling equipment is the air-cooled heat exchanger. These units are particularly applicable where high-level heat removal is desired, e.g., gas cooling 250 to 120 F and water cooling 165 to 150 F; also where water is scarce or expensive to treat, or where low operation and maintenance costs are of particular significance.

Air As a Cooling Medium

As compared with water, air is everabundant, easy to handle, and physically stable. Its impurities are seldom such as would foul or corrode the equipment served except under conditions of unusual air contamination. There is no upper temperature limit to which air may be heated; the optimum heat transfer rate and permissible temperature limit may thus be made the maximum for which it is feasible to design the heat transfer surfaces of an air-cooled heat exchanger containing the fluid to be cooled by the air. The density of air is very much less than that for water, but the specific heat is only one-fourth that of water. The combined effect of the above factors results in reduced power requirements per unit of heat removal for a dry-cooling unit as compared to water-cooling equipment.

Water usage has more than doubled in the past decade and is still increasing by "leaps and bounds." Large water users include the petroleum industry, chemical processes, power plants, paper, rayon, rubber, explosives, atomic energy, hydrogen, steel, and many others. Today's cooling requirements of many process industries are frequently in excess of 300 lb of water per pound of product. Hence the selection of the most practicable cooling method for the reuse of water, or its elimination as a coolant, becomes more important as new processes are perfected, industries are expanded, and as power demands are increased.

Industrial Air-Cooled Equipment

The automobile has for years used an air-cooled "radiator" for cooling the engine jacket water by a combination of induced and forced draft. Stationary in-

*The Marley Company, Kansas City.

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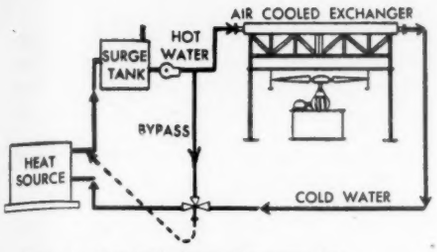


FIG. 1. Typical flow diagram for closed cooling system with forced-draft air-cooled heat exchanger; note thermostatic control.

ternal-combustion engines use induced draft air cooling of the jacket water. Heat in aircraft engines is usually dissipated by air alone and likewise in the household refrigerator. Most air conditioning installations reverse the idea by heating the refrigerant while cooling the air, but the principle is unchanged.

An air-cooled heat exchanger is a device for cooling fluids by circulating them through finned tubes and passing atmospheric air across the finned tube sections. It is a dry-surface cooler with convection-type heat exchange. The finned tubes are usually made of copper, brass, aluminum, or steel, depending upon the service and the fluid to be cooled. One arrangement is the forced-draft unit, Fig. 1, with a propeller type fan discharging air upward and across a horizontal bank of finned tubes which are joined at both ends to flow-directing headers or manifolds. Another arrangement is the induced-draft type with the fan mounted on top of the unit, see right illustration at beginning of article.

The construction features and operating principles of water-cooled heat exchangers, both closed and open type are well known generally and will not be discussed here. Closed water-cooled exchangers for some services require cleaning on both sides of the tubes, while for air-cooled equipment the cleaning is confined almost entirely to the inside of the tubes where it is more readily accomplished. Pressure type shell construction and large flanged joints are eliminated because air-cooled sections require only supporting structure and light gage casings for containing the tube sections and directing the air flow.

Air-Cooled Exchangers

The need for air-cooled heat exchangers first became apparent in the Southwest and along the Pacific Coast, where water is scarce and generally of poor quality. Jacket water, lube oil, and gas coolers for gas-engine driven compressor installations, exhaust steam, and still condensers in field gasoline plants, and miscellaneous petroleum process units, all situated in such areas, represented early applications (about 1940) of large-size air-cooled equipment employing mechanical draft air circulation. Other diversified applications followed as manufacturers improved their equipment, and as designers and engineers realized the numerous advantages of dry cooling.

As operating practice developed, more and more advantages of air cooled units became apparent; other installations were made—as new, repeat, or replacement for water cooling. Also, where water was in limited supply, or required chemical treatment, and additional cooling was desired it was frequently better to use air cooling for at least the high temperature portion of the cooling load. For installations to serve the cooling requirements of engines or compressors that were housed in buildings, air-cooled units could be located closer to the buildings and other outdoor equipment than cooling towers because the water spray and driftage hazard would be eliminated.

Many varied applications of air cooled heat exchangers have been made during the past decade, especially in petroleum and allied industries for cooling all kinds of liquids, vapors, and gases at appropriate temperatures and pressures. The following list is typical.

1. Liquid Cooling
   a. Engine (compressor) jacket water
   b. Lube oil
   c. Absorption oil
   d. Stabilized crude
   e. Vegetable oil
   f. Cotton oil
   g. Cocoanut oil
   h. Quenching oil
   i. Amine solutions
   j. Transformer oil
   k. Bearing oil
   l. Glycol solutions
2. Natural Gas Cooling
   a. Pipe line compressor station
   b. Re-pressuring
   c. Underground storage
3. Vapor Cooling and/or Condensing
   a. Gasoline (straight, cracked, natural)
   b. Steam
   c. Still, reflux and overhead
   d. Debutanizer and depropanizer strippers.
   e. Ethane
   f. Ammonia

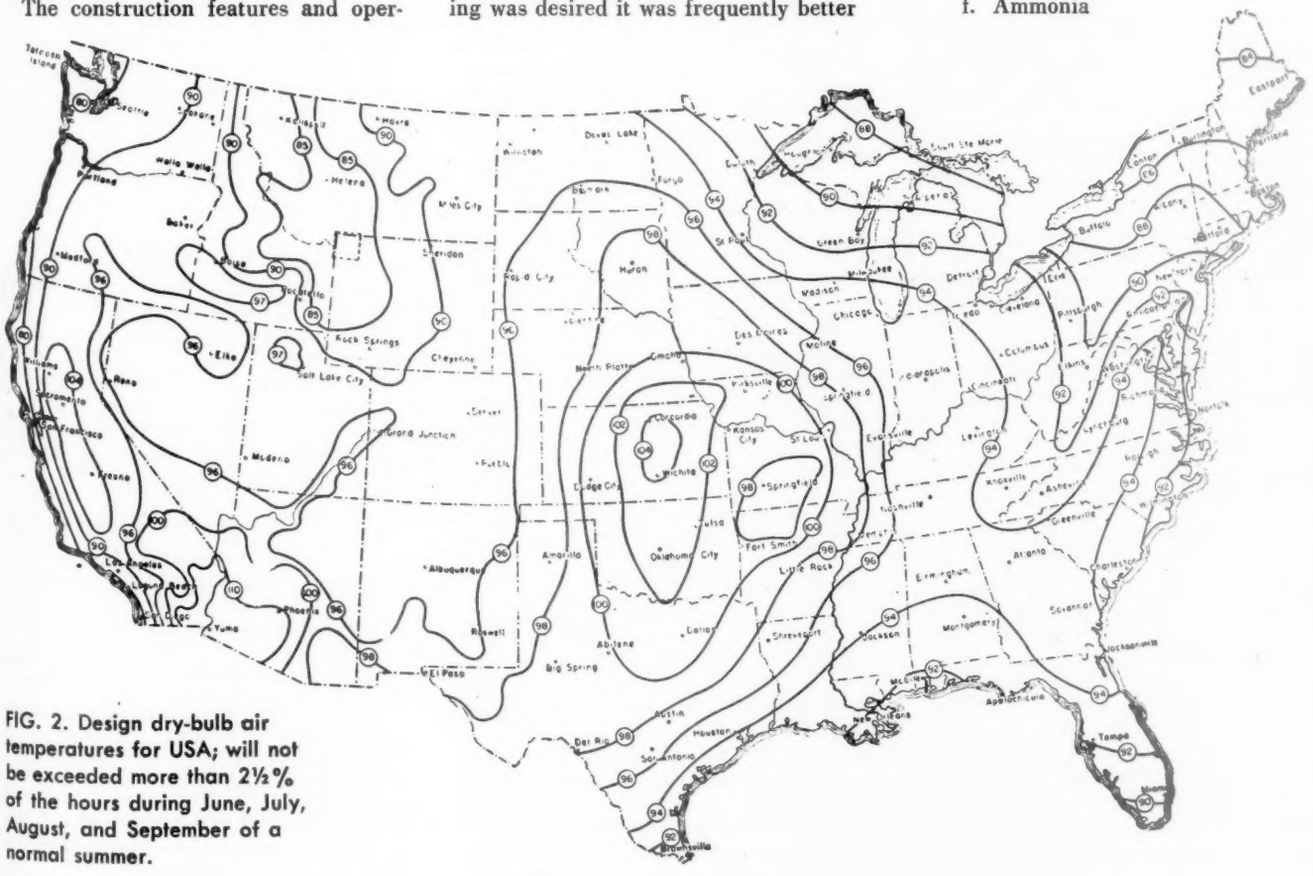


FIG. 2. Design dry-bulb air temperatures for USA; will not be exceeded more than 2½% of the hours during June, July, August, and September of a normal summer.

Selection of Air-Cooled Units

Design Air Temperature. Air cooled equipment should be selected for cooling the fluid to the highest final temperature that can be tolerated for short periods, using the "design dry-bulb air temperature" for the geographic location. When selecting the design air temperature for dry-surface coolers, it is generally acceptable to choose a dry-bulb temperature that will not be exceeded more than 2½ per cent of the hours during the months of June to September, inclusive. See Fig. 2 for suggested values. The temperatures that occur in excess of this design value would be of such short duration as not to have an appreciable effect on performance of the process or equipment being served. Frequently used dry-bulb design temperatures are 90 to 105 F.

The central part of California (typical example) is subject to hot days, see Fig. 2, and cold nights as well as the extremes of seasonal temperature changes. The problem, therefore, is to arrive at the most economical design dry-bulb temperature for an air-cooled exchanger and still consider the overall year-round plant economy. Fig. 3 provides a curve of dry bulb temperature incidence at Fresno, California; the ordinate indicates the design dry-bulb air temperature and the abscissa the per cent of this temperature occurrence during the summer months.

During a normal year, a temperature of 100 F is not exceeded more than 8 per cent of the summer hours in Fresno; see Fig. 3. If a design temperature of 110 F had been used, an air-cooled heat exchanger would have cost $100,000 for a given performance. With a design temperature of 104 F (recommended choice) the unit would cost $84,000, as indicated in Fig. 3. Below this point the reduction in cost becomes proportional to the reduction in dry-bulb temperature. Most processes will tolerate temperatures above the design value for short periods of time and the recommended 2½ per cent values of Fig. 2 have been generally accepted. If the process is not too critical, it may be desirable to use a lower design dry-bulb temperature in order to assure greater economy.

No overload factor for unit capacity should be applied to the dry-bulb design temperature, because it is difficult to evaluate this type overload factor in terms of actual plant performance. It would be better to increase the heat load and fluid quantity while holding the hot and cold fluid temperatures constant; or in the case of constant-flow process cooling the heat load could be increased and the cold fluid temperature lowered accordingly.

Design Types. When selecting an air-cooled unit, several physical and mechanical features should be examined. The following design considerations and operating characteristics indicate the advantages and disadvantages of the forced draft and induced draft arrangements for air-cooled heat exchangers.

increase, whereas the opposite is true at the lower end. The optimum size would be somewhere between the two extremes and could be determined as follows.

Assume that power costs are $200 per brake horsepower for the life of the equipment; the $100,000 unit in Fig. 4 requires 130 bhp which would cost 130 × $200 = $26,000 for total power requirements of this unit. Calculations for units 1, 2, 3, and 4 of Fig. 4 have been tabulated to the left of Fig. 5 and the curve on the right shows the variation of power evaluation costs with purchase price. For the assumed performance, the optimum size is the second unit (low point on curve in Fig. 5) at a

Induced Draft	vs	Forced Draft
1. Less recirculation of exit air.		1. Mechanical equipment is simpler and more easily accessible.
2. Better air distribution over finned tube sections.		2. Simpler structure.
3. Finned tube sections close to ground, easier to maintain.		3. Isolated support for mechanical equipment.
4. Maximum protection from rain, hail, and sub-freezing weather.		4. Readily adaptable to other than electric motor drive.
5. Walkway unnecessary.		5. Less fan power required for same performance.
6. Less connecting piping.		6. Sections more easily removed for major repairs.

Fan Horsepower. Fans are rated upon the volume of air delivered at standard conditions of temperature and pressure. Heat transfer calculations are based on the weight-rate of air moved, hence a fan rated at 50,000 cu ft per minute delivers 3800 lb of air per minute at 60 F. This fan in a forced draft unit would supply 3430 lb of air per minute at 90 F, and the same fan in an induced draft unit would supply only 3240 lb per minute at 150 F. Therefore if induced draft were used the fan would require about 6 per cent greater volume of air (at increased power) than in a forced draft unit to circulate the same weight of air for a given heat dissipation.

For a given application it is possible to purchase a unit with large cooling surface and requiring small amount of power, or a smaller unit with large power usage for the fan drive, see Fig. 4. The curve in Fig. 4 rises sharply at the top, which indicates that a small reduction in power requires a high price

cost of $90,000. In general, economic selection favors large first cost installations with low horsepower unless power rates are favorable.

Fan Speed Controls. Another factor of importance is the type of fan drive selected. Most applications employ electric motors. Economies result from the use of two-speed motors, that can be operated at half speed during a large part of the year, thereby reducing the power costs as much as 75 per cent when so operated. Where close control

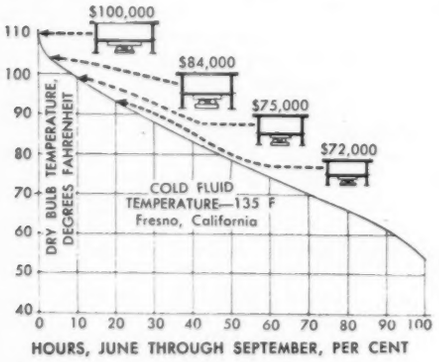


FIG. 3. Design dry-bulb air temperature effects purchasing price of cooling unit.

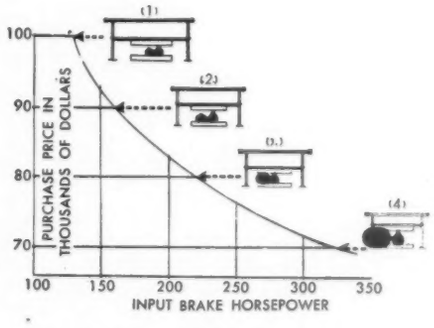
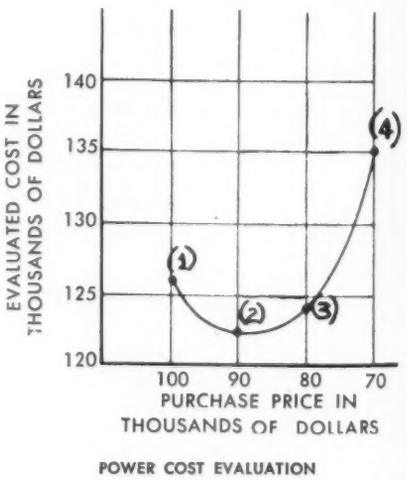


FIG. 4. Power requirements of air-cooled units as related to purchase price, for the same performance.



POWER COST EVALUATION

			Total
(1)	Unit Price	$100,000	$126,000
	Power Cost	26,000	
(2)	Unit Price	90,000	122,400
	Power Cost	32,400	
(3)	Unit Price	80,000	122,800
	Power Cost	44,800	
(4)	Unit Price	70,000	135,200
	Power Cost	65,200	

FIG. 5. Power cost evaluation of air-cooled units as related to purchase price for same performance.

of performance is desired by adjustment of fan air delivery, variable speed drives may be used.

The advantages of using speed controls are indicated in Fig. 6. The curves are for an installation in Pennsylvania, where the design dry-bulb temperature is 94 F. Full speed of the driver is 1750 rpm. The fan requires 19½ hp for rated performance of the unit. If manual control were used with a two-speed motor, operation at full speed would be required for air temperatures above 63 F, see Fig. 6. At all temperatures below this point, the fan would operate at half speed; the change would be made manually. At half speed, the fan requires only 3.3 hp and the usage would be about 5700 hr per year as estimated from the scale at the top of Fig 6; full speed usage approximates 300 hr.

The broken line curve in Fig. 6 shows the variation of power required for a thermostatically controlled two-speed drive that takes advantage of the decrease of air temperature below the design dry bulb. This control method is adaptable to a recirculating service where the cooling unit can take advantage of the fly-wheel effect of the system, if the fluid temperatures were allowed to vary within reasonable limits.

The curve on the right in Fig. 6 shows the ultimate in regulation and power conservation; the speed of the fan is automatically controlled with a variable speed drive to maintain a constant fluid temperature for all dry-bulb air temperatures. Where the power costs are high the more complex and costly variable speed drive would be justified, especially for large cooling units.

Additional use of the curves in Fig. 6 is to determine the power usage factor, or per cent of full speed power consumed annually. A usage factor of 50 per cent for an air-cooled unit is general where two-speed motors are employed. This means that the power actually consumed (regardless of speed) is about half of that required if the fan were operated full speed throughout the year.

Design Details. Table 1 includes a number of important details which should be considered when preparing a set of specifications for an air-cooled exchanger.

Specifications. When preparing specifications for a dry-surface air-cooled unit, one of the most important considerations is the choice of temperature-level at which the heat is to be transferred. Operating practices have generally been developed on the water-cooled (cooling tower) basis; these can be similarly applied for air-cooled heat exchangers. Water can be cooled economically in a cooling tower within 5 to 10 degrees of the air wet-bulb temperature, hence a cold raw water temperature of 80 to 90 F is a typical desired requirement.

Lower raw water temperatures than actually needed are frequently specified with cooling towers because higher cold-water temperatures would not appreciably decrease the overall cost of the cooling equipment (tower plus shell-tube exchanger); e. g., cold raw water temperatures could require a small shell-tube exchanger and a large tower. If higher raw water temperatures were used the cooling tower cost would be reduced but a larger shell-and-tube exchanger would be required, hence total costs would be about the same as for low water temperatures from the tower.

A closed engine-jacket water-cooling system with atmospheric sections in base of tower would cost about $7 per gallon per minute for cooling jacket water from 150 to 140 F with a 75 F wet bulb of ambient air. This cost would be decreased approximately $1 per gallon per minute if the jacket water temperature level were increased by 20 F. The power required for operating the cooling tower fans and pumping the water would remain about the same. A finned-tube air-cooled unit for cooling the engine jacket water from 150 to 140 F with air at 100 F dry bulb would cost about $15 per gallon per minute, but would decrease to $10 per gallon per minute if the jacket water temperature level were increased by 20 F. There would be a proportional decrease in power required for the fans. The saving in first cost of an air-cooled heat exchanger for cooling the jacket water of a 1000-hp engine would be at least $3000 by specifying a 20 F higher temperature level, plus an additional saving of power costs for fan operation. Also, higher operating temperatures of the engine should improve combustion of its fuel with increased thermal efficiency.

Engineering specifications for air-cooled heat exchangers should include details of: (1) performance data, (2) finned tube sections, (3) mechanical equipment, (4) structural requirements, (5) type of power drive, (6) special features, and (7) evaluation information.

Typical design performance data to be provided includes—location of installation, dry-bulb temperature, elevation, fluid to be cooled, heat load, hot fluid temperature, cold fluid temperature, quantity circulated, operating pressure, allowable pressure drop, and possibilities of inside fouling. For process cooling services, all available physical properties should be included.

The heat exchanger sections should be specified as to tube and fin material desired, type of finning and fin-to-tube bond, design and test pressures, kind of inlet and outlet connections, drain and

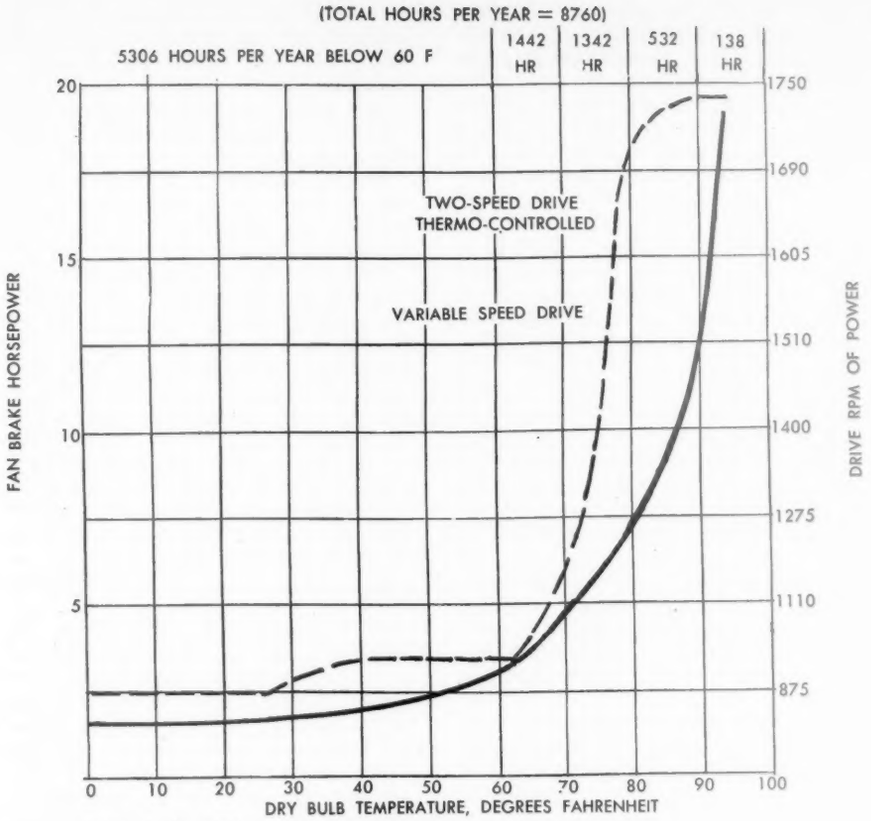


FIG. 6. Variable speed drives (for air-cooled heat exchangers) reduce annual power costs; fan horsepower required decreases with ambient air temperature.

TABLE 1. Important design details for air-cooled exchangers that affect cost.

1. Fin Tube Sections	a. Tube material and thickness. b. Fin material, size and shape. c. Fin bond efficiency. d. Header type and pressure. e. Type of piping connection.
2. Air Moving Equipment	a. Power source. b. Power transmission to fan. c. Number of fans. d. Fan material and design.
Structure	a. Slab or pier foundation. b. Forced or induced draft design. c. Structural stability. d. Ladders, walkways, handrails. e. Belt, shaft, fan guards.
4. Controls	a. Temperature control instruments. b. Power control instruments. c. Louvers, rolling doors. d. Mixing valves.

vent provisions, intermediate tube supports, and tube to header joint details.

Mechanical equipment requirements should include type of fan (generally multi-blade, adjustable pitch), blade material, spiral-bevel gear reduction unit or V-belt drive (the latter may be used for less than 15 hp fan drive), and type of connection between motor and gear reduction unit.

Structural requirements should be stated as to induced or forced draft preference, wind pressure (usually 30 psf), framework and casing materials, air seals, partitions, hardware materials, painting, etc.

The type of power drive desired should be requested as to electric motor, steam turbine, or internal-combustion engine. Two-speed electric drives for fans are frequent; power savings may be effected with engine or steam turbine drive where greater speed flexibility is possible.

Special features which could be specified are: rolling steel doors or shutters for winter protection, access ladder, walkway, handrail, chain-link type fence enclosure, or fan guards and belt guards.

If evaluation of equipment is to be made by the engineer, specifications should state the period of amortization, unit cost of power, and the applicable usage factor.

Costs and Evaluation

A comparison of costs between a large air-cooled heat exchanger and a water cooling tower for equivalent use is frequently difficult and may require detailed study. To obtain an estimate, a complete analysis must be made; purchase price, power costs, water cost, maintenance, etc., are evaluated over the life expectancy of the equipment. The following example is a typical evaluation to show the relative costs of air-cooled heat exchangers and cooling towers for engine jacket water cooling.

Example. Make tabulations showing (1) the installed costs and (2) 15-year amortization costs of an air-cooled exchanger and a cooling tower (with atmospheric tube section at bottom), each to cool the jacket water of a 10,000 hp two-cycle diesel engine. The water is to be cooled from 155 to 140 F. Make necessary estimates for cooling tower (45 per cent fan use factor) with tube sections at base and air-cooled unit (50 per cent fan use factor). Use 93 F as dry-bulb and 78 F wet-bulb design air temperatures. The raw water temperatures over the cooling tower tube sections to be 90 to 105 F. Power rate, 1¼ cents per kwh; 3 per cent make-up water for tower; air-cooled unit requires annually make-up water about 10 times the water circulated per minute. Tower use would require a new deep well and pump; water treatment averages 2 cents per 1000 gal of make-up water; insurance at 2 per cent; taxes at 1 per cent; and maintenance at 1 per cent for the tower and ½ per cent for dry cooler. Assume 95 per cent average annual operating time.

Table 2 shows the itemized cost of a water-cooled system compared with that of a complete air cooled unit, for identical cooling capacity. The first two items indicate that the installed price of the cooling tower would be considerably less than that of the air-cooled heat exchanger for the above conditions. To complete the required cooling tower interconnected auxiliaries, it is frequently necessary to provide a deep well water supply and a pump in addition to a raw water pump and chemical treating facilities for the make-up water.

A comparison of the itemized operating costs of the two types of cooling systems indicates that for this application the water-cooling tower would require more power, water treatment, and increased maintenance costs than for the air cooled unit. The annual evaluated cost of the air-cooled heat exchanger, for a life expectancy of 15 years, would be about 14 per cent less than with a cooling tower; this would be reduced to 10 per cent if no investment were necessary for a deep-well water supply.

Conclusion

It is impossible to formulate any set of recommendations that would definitely establish the selection of a given cooling method as being the most suitable for any particular application. The anticipated performance, power requirements, operating features, ease of maintenance, and correlated features of a proposed installation should be completely analyzed. A careful evaluation of the applicable types of cooling equipment should be made to insure that the most suitable cooling equipment is selected in each case. Frequently, the final choice becomes a matter of engineering compromise and personal preference. It is significant that, as the need for water conservation increases, the manufacturers of cooling equipment have been accumulating a great reservoir of experience by continuously making more economical units and more highly specialized applications.

The time-honored and practical method of writing specifications and asking for complete cost and performance data on the equipment offered is the best plan to obtain accurate and competitive cost information for the economic selection of industrial cooling equipment. The question will inevitably arise as to whether or not the lowest of competitive bids should be accepted, or whether a better quality should be selected at a higher price. In this regard it may be difficult to frame any better statement than the observation of John Ruskin, "There is hardly anything in the world that some man cannot make a little worse and sell a little cheaper; and the people who consider price only are this man's lawful prey." The effectiveness of rigid specifications and selective purchase, however, can only be determined from the actual performance of the installed equipment. * * *

TABLE 2. Installation costs of air cooled heat exchanger and water cooling tower to provide equivalent cooling of 10,000 hp diesel engine.

Installed Cost Items	Air Cooled Heat Exchanger	Cooling Tower with Coil Shed
Delivered and erected price	$58,210	$37,360
Foundation (concrete basin for tower)	1,125	2,925
Soft water piping	2,800	1,930
Raw water piping	—	800
Valves	7,200	5,040
Soft water pump with motor	1,885	1,885
Raw water pump with motor	—	1,700
Deep well and pump with motor	—	10,000*
Controls and electrical work	860	1,040
Total installation cost	$72,080	$62,680

* Well and pump not required if city or other make-up water is available.

TABLE 3. Evaluation costs of air cooled exchanger and cooling tower for cooling of 10,000 hp diesel engine.

Itemized Operating Cost	Air Cooled Heat Exchanger	Cooling Tower with Coil Shed
Equipment cost, from Table 2	$ 72,080	$ 62,680
Fan horsepower	38 hp (50% use)	17 hp (45% use)
Pump horsepower, soft water	77 hp	77 hp
Pump horsepower, raw water		33 hp
Pump horsepower, well and make-up		8 hp
	115 hp	135 hp
$Kw = \frac{Hp \times 0.746}{0.90 \text{ motor eff.}}$	95Kw	112 Kw
Power costs, 15 yr	$148,000	$175,000
Maintenance (½ and 1%), 15 yr.	5,400	9,400
Water treatment cost, 15 yr	100	19,500
Insurance, 15 yr	21,600	18,800
Taxes, 15 yr	10,800	9,400
Total operating costs, 15 yr	$185,900	$232,100
Equipment costs, Table 2	72,080	62,680
Grand totals	$257,980	$294,780
Annual Evaluated Cost of Operation and Amortization	$17,200	$ 19,650

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Determination of Sulfur in the Presence of Halogens

RAYMOND R. JAY†

THIS method is a modification of the lamp CO_2–O_2 procedure[3] to include the accurate and rapid determination of sulfur in materials containing halogens. It is especially applicable to the analysis of leaded gasolines containing halogens as lead scavengers. A correction for halogen interference is made either by titration with silver nitrate or by calculation based on the content of tetraethyl lead.

Theory and Development of the Method

The combustion of lamp sulfurs in the usual atmosphere of purified air leads to the formation of appreciable quantities of nitric acid, which gives rise to high results when the analyses are completed by alkalimetric titrations[1]. In order to eliminate this error, which usually amounts to about 0.01 per cent sulfur for petroleum distillates[1], the official ASTM method[2] now employs a gravimetric determination of the sulfuric acid formed in the absorber. This procedure is accurate and does not suffer interference from nitric acid formation or from halogens contained in the sample. For speed and economy of labor, however, an alkalimetric procedure is much to be preferred.

The substitution of a mixed atmosphere of oxygen and carbon dioxide for the purified air eliminates the formation of nitric acid and makes possible the accurate determination of sulfur by titration with standard sodium hydroxide when the sample contains no other acid forming elements. The proposed method of the American Society for Testing Materials[3] makes no provision for interference due to halogens, which are converted to acids upon combustion.

The procedure outlined below makes due allowance for the halogen acids formed by determining the total acidity and then deducting the contribution of the halogens to this acidity. The halogen content is more accurately determined by the Mohr titration with silver nitrate after the usual alkalimetric determination. For leaded motor gasolines, however, it has been found empirically that a correction for halogens may be made based only on the tetraethyl lead concentration. This calculation has been found to give good results on many samples and may be applied as a close approximation if the T.E.L. content of the gasoline is known. It should not be applied to aviation gasolines.

Apparatus and Reagents

1. Shell-precision lamp sulfur apparatus or its equivalent. See reference (3) for complete details.
2. Cylinders of carbon dioxide and oxygen.
3. Three per cent hydrogen peroxide neutralized to the methyl red end point.
4. Methyl red indicator solution, 0.1 per cent.
5. Standard sodium hydroxide, carbonate free 0.0624 ± 0.0001 N.
6. Potassium chromate indicator solution, 10 per cent.
7. Standard Silver Nitrate, 0.0624 N.
8. Yellow Filter, Kodak Wratten K-2.

†Sinclair Research Laboratories, Inc.

Procedure

The apparatus is prepared and samples are burned essentially according to the proposed method of the ASTM[3]. The following exceptions have been used to advantage in the author's laboratory.

(a) The vacuum manifold is operated at a pressure of 3 in. of mercury below atmospheric. This greater pressure differential has been found to give more uniform operating conditions.

(b) The pressure in the chimney manifold is regulated at about 1½ to 2 in. of water.

For the usual leaded gasolines, which may contain from 0.05 to 0.15 per cent sulfur, about 10 g of sample are burned. This requires about 2½ hr burning.

After the desired amount of sample is burned, the absorbent solution is flushed free of CO_2 as in the ASTM procedure. In the case of leaded gasolines, the chimney deposit is *not* washed into the absorber as this would interfere in the silver nitrate titration that follows. The absorbent is titrated as usual with 0.0624 N sodium hydroxide to the methyl red end point. Care should be taken to add only a minimum amount of indicator so as not to obscure the chromate end point of the halogen titration to follow.

After completion of the alkalimetric titration, the solution is transferred quantitatively to a 250-ml beaker keeping the volume of wash water as low as possible. About 1 ml of potassium chromate indicator is added and the solution is *immediately* and *rapidly* titrated with the standard silver nitrate using a yellow filter to aid in the detection of the end point. (Note: The residual hydrogen peroxide in the solution may react with the chromate to give a dark color upon prolonged standing.) A blank titration should be run on an equivalent volume of solution containing a like amount of hydrogen peroxide.

Calculations

$$\% \text{ S} = \frac{(\text{ml. } 0.0624 \text{ N NaOH}) - (\text{ml. } 0.0624 \text{ N } AgNO_3)^*}{(\text{grams sample}) \times 10}$$

*Corrected for titration blank.

For the usual commercial leaded motor gasolines, regular or premium grade, the halogen titration may be omitted for routine work if desired and the per cent sulfur calculated as follows, provided the T.E.L. content is known:

$$\% \text{ S} = \frac{(\text{ml. } 0.0624 \text{ N NaOH})}{(\text{grams sample}) \times 10} - 0.00585 \text{ (TEL)}$$

where (TEL) represents the tetraethyl lead content in cc per gallon.

TABLE 1. Comparison of results on leaded gasolines.

TEL cc/gal	Per cent S (vol, uncorr)[1]	Per cent S (grav)[2]	Per cent S by proposed method: Halides titr.	Per cent S by proposed method: By calculation
0.68	0.038	0.033	0.033	0.034
0.80	0.037	0.030	0.030	0.032
0.60	0.037	0.032	0.031	0.033
0.94	0.022	0.013	0.015	0.016
1.78	0.043	0.031	0.031	0.033
1.72	0.041	0.031	0.029	0.031
1.34	0.063	0.052	0.054	0.055
1.20	0.028	0.019	0.020	0.021
1.25	0.049	0.043	0.042	0.042
1.09	0.025	0.017	0.018	0.018
0.79	0.043	0.035	0.036	0.038
1.78	0.305	.....	0.291	0.295
2.36	0.037	.....	0.020	0.023
2.12	0.161	.....	0.146	0.149

Notes: 1. Lamp CO_2-O_2, titration uncorrected for halogens[3].
2. Lamp gravimetric[3].

Results

The above method has been used for several years in the author's laboratory and has been found to give results which are in good agreement with those obtained by the lamp-gravimetric method[2], as indicated by the data presented in Table 1. Failure to correct for halogen content leads, of course, to high results for sulfur. It may be seen from Table 1 that correction for halides becomes increasingly important for low sulfur and high TEL fuels.

Discussion

The empirical factor used to calculate the halide correction was derived initially from a series of 12 samples of gasolines. These were burned in lamps in the usual manner and titrated for halogens. The TEL values were obtained by polarographic analysis. These results showed conclusively that the halide content could be correlated with TEL content closely enough to be of value in this work. Many subsequent tests using the correction factor have checked well with actual titrations. Due to the fact that any correction for halogens by calculation depends upon the constancy of the ratio of halogen scavengers to tetraethyl lead, it is felt that for most accurate work the actual titration should be used as the halogen correction.

Literature Cited

1. American Society for Testing Materials Standards on Petroleum Products—ASTM Designation D90-46T.
2. Ibid.—D90-50T.
3. Ibid.—Appendix VI, p. 1330, 1949 edition.

* * *

News

Phillips Petroleum Will Expand Utah Refinery

Plans for a 50 per cent expansion of its Woods Cross, Utah, refinery have been announced by Phillips Petroleum Company. K. S. Adams, chairman, made the announcement while attending dedication of a $10,000,000 catalytic cracker at the Woods Cross plant. The new cracker increased crude oil capacity of the refinery from 5000 to 12,000 bbl daily. Adams noted that the cracker will permit expansion to a capacity of 18,000 bbl daily, and that this expansion likely will take place in 1954.

Chemists Develop Method For Measuring Oxygen

Morris Dundy, a Texas Company chemist at Beacon, New York, and another Texaco chemist, Ervin Stehr, have designed apparatus for the direct determination of oxygen. The traditional method has been to measure the amounts of other elements present in a sample substance and by subtraction to arrive at the estimate of the oxygen present.

The new analysis is particularly valuable in the field of technical service where rapid studies are needed of products in service. The Dundy-Stehr apparatus provides Texaco's main research center an unusual research tool which is all the more useful for its ability to analyze minute samples — the only amounts available in many instances. A modification of the Schutze-Unterzaucher method, the Texaco system overcomes the major defect inherent in the earlier method—inaccuracy. Dundy and Stehr found that relatively high oxygen measurements from materials known to contain little or no oxygen were obtained from the previous direct measurement technique.

Egloff Lectures in Spain

Dr. Gustav Egloff of Universal Oil Products Company, was recently invited to give a series of lectures in Spain. He addressed the Instituto del Combustible (Institute of Fuels) Madrid, on "Present and Future Motor Fuels and Lubricants;" the Instituto "Alonso Barba" de Quimica, Madrid, on "Catalysis in Petroleum Refining," and the La Laguna University, Teneriffe (Canary Islands) on "The Evolution of Petroleum Refining Technology."

New Crude Unit at Martinez

A new crude distillation column that will increase total capacity by 10,000 bbl a day has been put "on stream" at Shell Oil Company's Martinez refinery.

The new unit, along with auxiliary equipment, cost more than a quarter of a million dollars, and boosts the refinery's capacity to approximately 70,000 bbl a day, manager John A. Tench stated.

The column is an integral part of a distillation plant that separates crude petroleum stocks into gasoline components, solvents, kerosines, stove oils, and cracking stocks. It was manufactured by the C. F. Braun Company.

The Martinez distillation column is the initial project in Shell's program to increase West Coast refining capacity, and is part of a $100,000,000 nation-wide expansion program that will eventually add some 4,000,000 gal daily to the nation's petroleum output.

In addition to the distillation column, Tench also announced that a new $150,000 acid-treating unit has been installed.

Thermostats to Measure Liquid Level Developed

An ingenious use of thermostats solved the problem of keeping a continuous check on the operation of a liquid level controller in a hot asphalt tank and of giving visual alarm in case the controller fails to function. The thermostats were adopted because the high temperature and extreme viscosity of the asphalt interferes with the operation of most level indicating instruments. This system of level indication was devised by engineers at the Flintkote Company of East Rutherford, New Jersey.

Two rows of Thermoswitch units, each containing 11 units spaced 6 in. apart, are mounted on opposite walls of the tank. The rows are staggered vertically so that liquid level is actually measured at three-inch intervals. The thermostats, manufactured by Fenwal Incorporated of Ashland, Massachusetts, are connected to a set of three pilot lights. By means of prong-type connectors, the plant men can connect any three thermostats to the three pilot lights, depending on which liquid level is required for a particular operation. The height of the liquid level is varied to govern the amount of penetration of the saturant in the siding material, isasmuch as the siding picks up the asphalt by passing vertically down one side of the tank and up the other. The Thermoswitch units follow the position of the liquid level by responding to the temperature of the asphalt and are set at approximately 375 F to operate the pilot-light circuits.

Shell's new distillation column at the Martinez refinery just before scaffolding is removed.

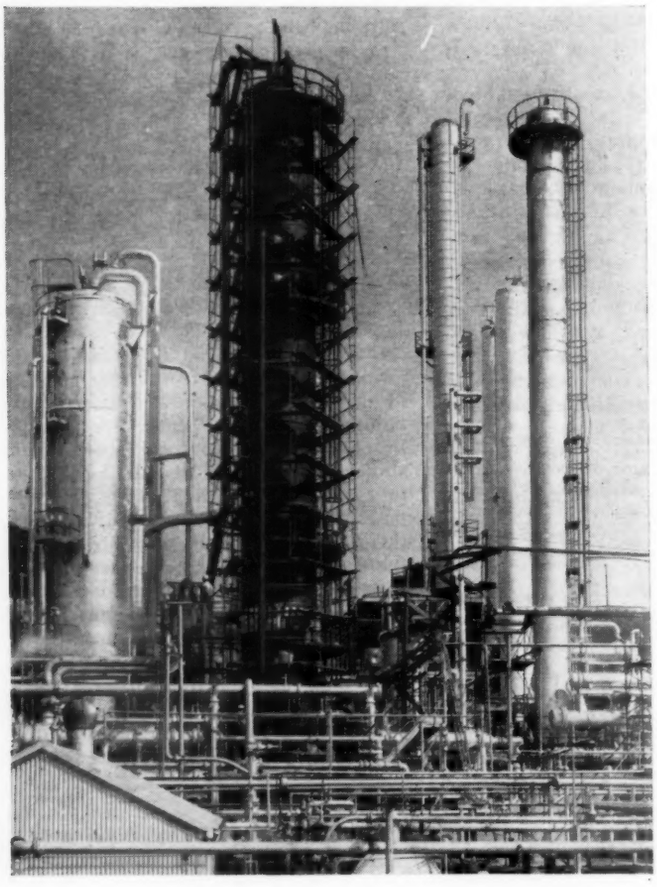
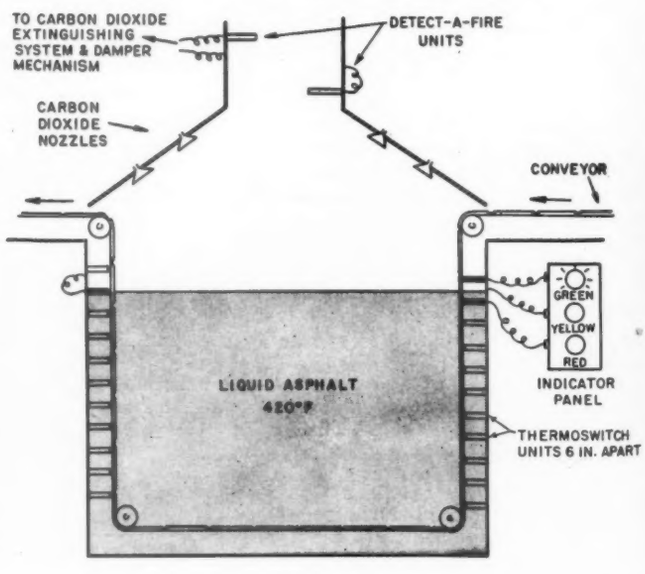


Diagram of thermostat used to measure liquid level.



Suntide Unit Progressing

Foundations for the 30,000 bbl crude topping unit, vacuum unit, and 15,000 bbl per day catalytic cracking unit, which will be the heart of the Suntide Refining Company's new refinery being constructed at Corpus Christi, Texas, have been completed. Building progress on the plant site is proceeding rapidly with some area work as much as 60 days ahead of schedule, it has been announced by Floyd L. Martin, president of Suntide.

Design, drafting, and purchasing necessary to point operations to the early fall of 1953 are proceeding on schedule and foundations are also ready to receive the construction steel for the crude tower, the vacuum unit, absorber and miscellaneous service buildings. All steel for sixteen 80,000-bbl various storage tanks is on the ground.

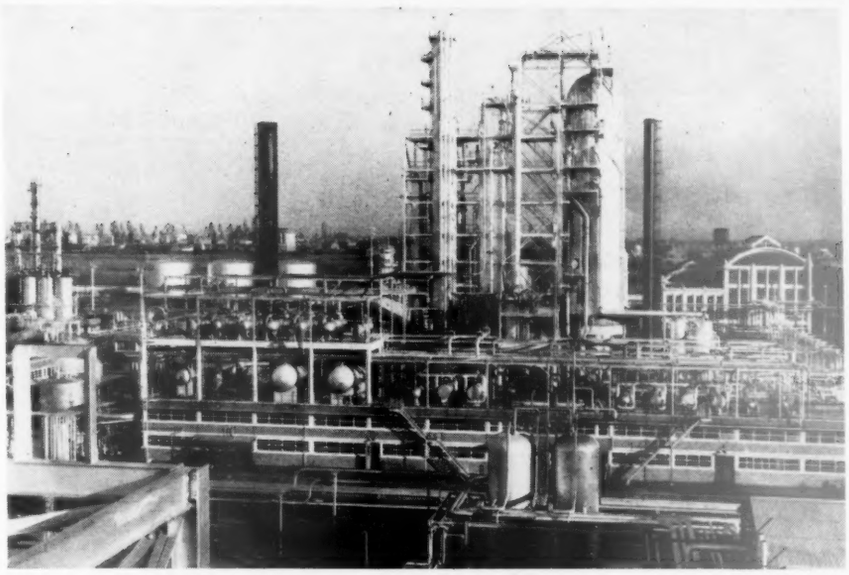
Gulfs Opens New Sulfur Recovery Unit

Gulf Oil Corporation has placed in operation a new sulfur recovery unit with a daily capacity of 134,400 lb at its Port Arthur, Texas, refinery. The unit is designed to recover more than 90 per cent of the sulfur content of refinery "off-gases," which were formerly burned for heating. Sulfur extracted from them will be converted into sulfuric acid used in the alkylation process for producing high-octane aviation gasoline.

Sinclair Completes New Sulfur Extraction Unit

Sinclair Refining Company has announced completion of a new sulfur extraction unit at its Marcus Hook refinery. The unit, which converts hydrogen sulfide gas into marketable sulfur of high purity, has a rated capacity of 21 tons of molten sulfur daily.

Molten sulfur from the process is stored in an underground tank with a capacity of more than 125 tons. To prevent solidification, the tank is equipped with heating coils which maintain an even temperature.



Out of the Ruins of War stands the new Anglo-Iranian oil refinery at Dunkirk, France. AIOC dedicated its new $50,000,000 oil refinery at Dunkirk recently on the site of the plant, which was almost totally destroyed during World War II.

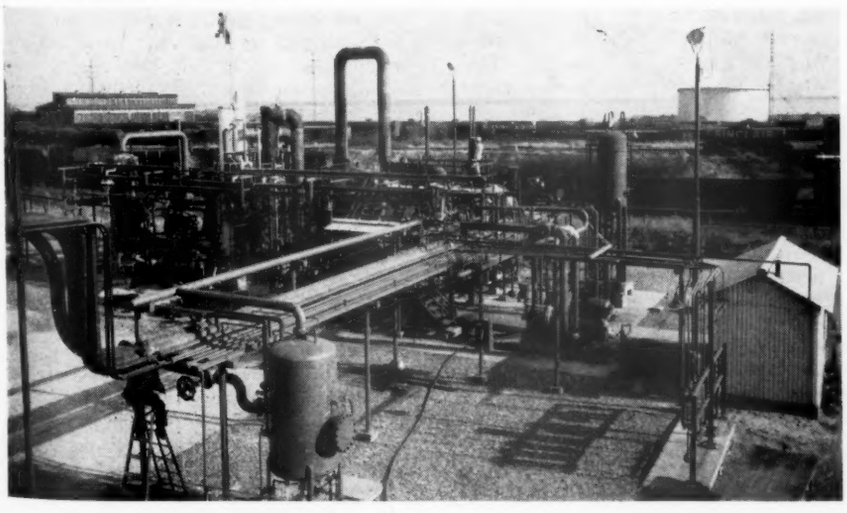
Caustic Regenerator Unit Licensed by ADC to ARAMCO

A unit for the operation of the ADC electrolytic process for spent treating caustic regeneration has been licensed by American Development Corporation to Arabian American Oil Company, Joseph H. Salmon, president of ADC announces. The unit will be designed to treat 25,000 bbl per day of spent caustic, and will be installed at the Arabian American refinery at Ras Tanura, Saudi Arabia. Its choice is the result of tests carried out by the company over a period of one and one-half years, which included comparison with other methods for caustic regeneration. A commercial unit using this process has been in operation for more than a year at the Catlettsburg, Kentucky, refinery of Ashland Oil and Refining Company. (Article discussing this process published in Petroleum Engineer, Reference Annual, 1952, page C-11 et seq.).

APCO Buys Kanotex Refinery

Anderson-Prichard Oil Corporation has purchased the Kanotex Refining Company of Arkansas City, Kansas, it was announced by Roland V. Rodman, president of Apco. C. M. Boggs, president and general manager; R. R. Cox, treasurer, and W. L. Lesh, vice president and sales manager, Kanotex, have retired.

Sinclair Extraction Unit recently completed at Marcus Hook, Pennsylvania, refinery. Adjacent to the tanks is a truck loading rack through which sulfur is pumped into tank trucks for delivery.



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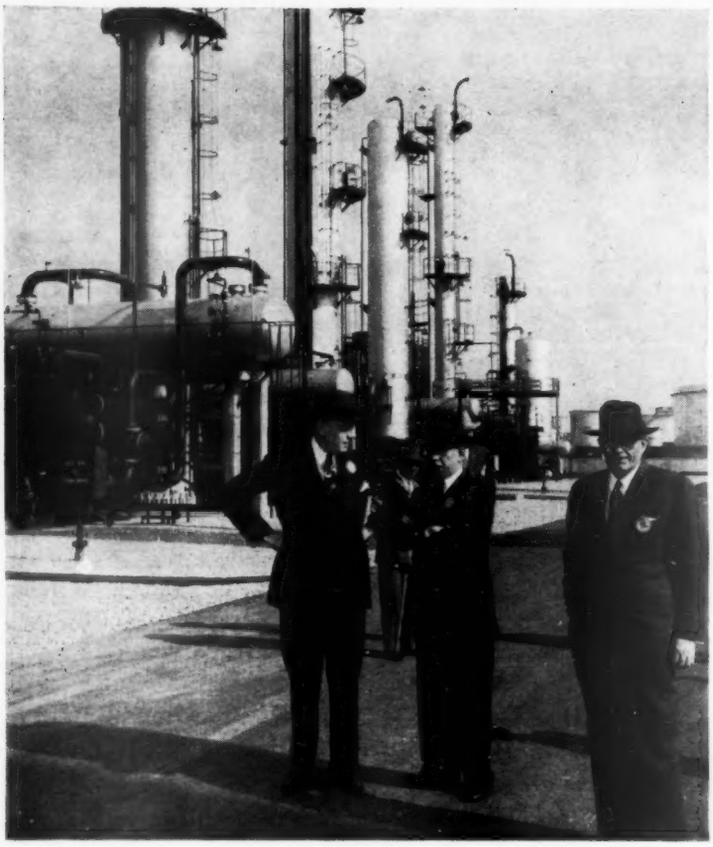
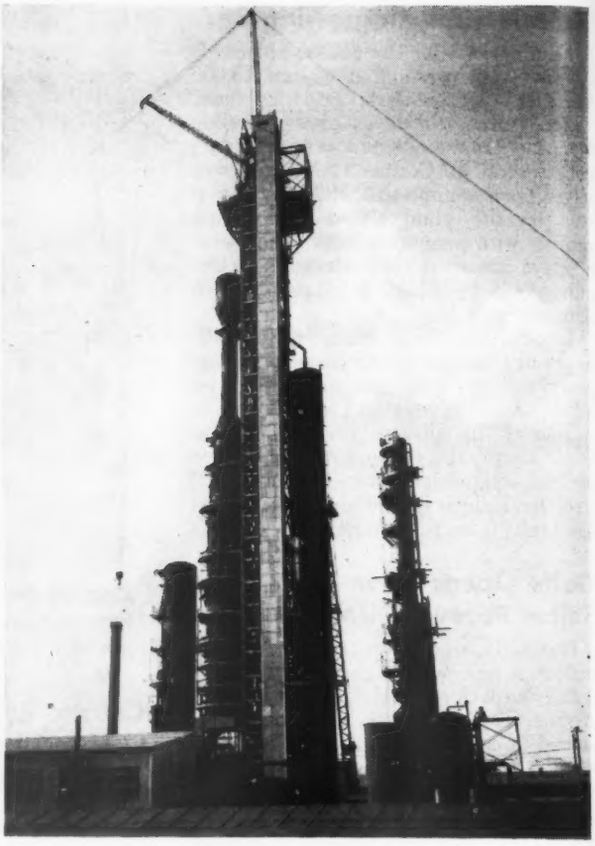


A. N. Kemp, director, George Parkhurst, vice president, and C. A. Pollard, general manager, inspect El Segundo refinery.



Houdriflow cat cracking unit nearly completed at El Paso, Texas, has 11,500 bbl a day capacity.

Platforming Unit on Stream At El Segundo Refinery

Standard Oil Company of California placed a UOP Platforming unit on stream at its El Segundo, California, refinery early in December. The 12,000-bbl per day unit will be the largest Platformer yet placed on stream.

The unit will operate on a blocked-out basis, producing high octane motor fuel approximately half the time and an aromatic concentrate during the other period. When operating for motor fuel output, the unit will charge approximately 12,100 bbl per day, with a yield estimated at 10,720 bbl of debutanized motor fuel.

On its aromatics run, the Platformer will charge 10,200 bbl per day with an estimated yield of aromatic concentrate of 8740 bbl. Standard will separate benzene and toluene from this concentrate through their own facilities.

Construction of the unit was handled by Procon Inc.

New Canadian Plants

To care for its expanding crude oil production in the Saskatchewan Coleville and adjacent Eureka, Driver, Buffalo Coulee, and Kerrobert fields, Canada Southern Oils Limited announces that, together with the Royalite Company, with which it shares ownership of the Coleville field, it has purchased a refinery in Prince Albert, 88 miles north of Saskatoon. To that plant, which has a 1000-bbl daily capacity, much of this year's yield of the Coleville field has been going.

It is expected that an independently operated topping plant will be erected in the Coleville environs during the coming year, which will have a capacity of 5000 bbl daily. Operators will take 3000 bbl daily of Coleville crude and the balance of 2000 bbl earmarked for markets that Canada Southern and Royalite anticipate developing jointly. A farm-out arrangement with Trans-Empire Oils Ltd. refinery at Moose Jaw, Saskatchewan, already has developed a new market for crude from the Buffalo Coulee field.

Petrochemical Firm Formed

The establishment of Goodrich-Gulf Chemicals, Inc., a Delaware corporation, by Gulf Oil Corporation and the B. F. Goodrich Company was announced by S. A. Swensrud, president of Gulf, and John L. Collyer, chairman of the board and president of Goodrich.

Stock ownership will be held equally by the parent organizations.

Goodrich-Gulf Chemicals, Inc., has been organized to explore projects in the petrochemical field.

Head office will be in Pittsburgh. Directors of the new company are: William G. Moore, L. O. Crockett, H. P. Hobart, and Allan B. Sloss, all of Gulf Oil Corporation; and John R. Hoover, R. G. Jeter, W. S. Richardson, and Frank Schoenfeld, all of Goodrich.

A plant site for the new company is being obtained at Orange, Texas.

Standard Texas Installs Facilities Ahead of Date Set

New facilities installed recently by Standard Oil Company of Texas, at El Paso, Texas, include a synthetic crude unit and a houdriflow catalytic cracking unit—each rated at 11,500 bbl per day—a 7555 bbl per day vacuum flash unit, a gas recovery unit, and an alkylation plant.

One of the erection procedures that contributed greatly to speed construction was the use of the stairwell and elevator shaft of the houdriflow catalytic cracking unit as a pedestal for the guy derrick.

The other unusual practice was the timing of the construction schedule with the materials-delivery schedule so precisely that it was possible to set every major item of equipment in place as it arrived on the job. This saved the cost of double handling and reduced the requirements for storage space in the very limited construction area.

The orthodox construction practice for an installation of the type planned for Standard of Texas would have called for erection of a guy derrick of sufficient capacity and range to set top pieces of equipment on the Houdriflow catalytic cracking unit, which reached a height of 360 ft. The foundation, erection charges, and rental or depreciation of a derrick pedestal for such service frequently cost in the range of $50,000 to $65,000.

Catalytic Construction Company designed and constructed the new facilities.

PERSONALS

Carroll E. Gregg has been appointed general superintendent of plants for Texas Natural Gasoline Corporation.

Gregg was formerly with Geier-Jackson, Inc., of Dallas, Texas. At the time of his resignation he was supervising engineer in charge of gas cycling, oil refining operations, maintenance, and construction. He attended engineering school at the University of Kansas.

Gregg has served the natural gas and gasoline industry for a period of 23 years. In 1938, he joined Gasoline Plant Construction Corporation at Houston as an operating specialist and during the period of seven years with that company he was assigned to process design engineering on many projects.

William T. Nichols, director, general engineering department, Monsanto Chemical Company, has been elected president of the American Institute of Chemical Engineers for 1953. The chemical engineers also elected as vice president, **Chalmer G. Kirkbride,** president and director of Houdry Process Corporation; **Stephen L. Tyler** and **C. R. DeLong,** both of New York City, were re-elected executive secretary and treasurer respectively.

Four new directors were chosen by the members through a mail ballot to serve for a three-year term. They are: **E. V. Murphree,** president, Standard Oil Development Company; **George G. Oberfell,** a consultant of Bartlesville, Oklahoma; **William T. Dixon,** manager, design division, engineering and construction department, The Altantic Refining; **Lee Van Horn,** vice president, research and development, The Fluor Corporation, Ltd., Los Angeles, California. The new president has been with Monsanto Chemical since 1943, and prior to his position as director of the general engineering division was a technical assistant to the executive vice president of Monsanto. He was educated at the University of Pittsburgh where he received both a BS degree and his B. Chem. degree.

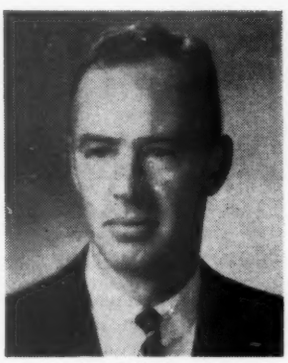
Thomas Baron, Shell Development Company, Emeryville, California, and **Lloyd G. Alexander,** Oak Ridge National Laboratory, Oak Ridge, Tennessee, have been chosen by the American Institute of Chemical Engineers to receive the 1952 Junior Award in chemical engineering.

The honor is given for outstanding contributions to the literature of chemical engineering, and Baron and Alexander will receive the award at a banquet of the American Institute of Chemical Engineers in Cleveland, Ohio. W. I. Burt, president of the AICHE, and vice president in charge of manufacturing for the B. F. Goodrich Chemical Company, made the formal presentation.

The selection of Baron and Alexander as recipients of the Junior Award was made by an award committee headed by Professor O. A. Hougen, University of Wisconsin. The award is made annually for "the paper judged most outstanding of those published by Junior members of the Institute during the last three years." The two young chemical engineers collaborated in a study entitled, "Momentum, Mass, and Heat Transfer in Free Jets."

George C. Debney

Max B. Tohline



David Dolson

George C. Debney, assistant chief engineer has been promoted to the position of chief engineer of Magnolia Petroleum Company's Beaumont refinery. He succeeds **Charles A. Knight,** who retired January 1 after 16 years as head of all design and mechanical engineering work at the refinery. Debney was graduated with an engineering degree from Rice Institute in 1930 and joined Magnolia the same year. He is a member of several engineering societies.

Max B. Tohline, chief design engineer at the Beaumont plant, will be Debney's successor as assistant chief engineer of the Beaumont refinery.

David Dolson has been named vice president in charge of crude oil supply of Mid-West Refineries, Inc. He also handles the pipe line transportation for all crude oils purchased by Mid-West. He will have complete responsibility for assuring adequate crude oil supplies for Mid-West. Dolson has been with Mid-West for the last two years.

R. E. Lauterbach

Richard E. Lauterbach has been named manager of the newly announced $35,000,000 Pacific Northwest refinery to be built in Ferndale, Washington, by the General Petroleum Corporation. Lauterbach is at present assistant manager of General Petroleum's Torrance, California, refinery. For the initial portion of the two year construction period of the 35,000-bbl daily Ferndale refinery, Lauterbach will make his headquarters at General Petroleum's home office in Los Angeles.

Lauterbach is a graduate of the University of California at Los Angeles. He joined General Petroleum immediately following graduation in March, 1936, as a laboratory assistant.

Paul Sanders has been named assistant manager of General Petroleum's Torrance, California, refinery. In addition it was revealed that **E. G. Surber** has been advanced to the post of superintendent of the plant. Sanders, a veteran of 33 years with General Petroleum, has been superintendent of the refinery since 1945. In 1929, Sanders and 33 men put the then tiny refinery "on stream" for the first time. Surber has been with General Petroleum since 1923. Since January, 1951, he has been foreman of the refinery's tank farm.

Arthur L. Lyman, vice president and director of laboratories of the California Research Corporation, has been elected chairman of the American Chemical Society's Division of petroleum chemistry for 1953. He succeeds **Frederick E. Frey,** assistant director of research of the Phillips Petroleum Company, Bartlesville, Oklahoma.

Professor **Frederick D. Rossini** of the Carnegie Institute of Technology was chosen chairman-elect, and **Dr. Alex G. Oblad,** director of chemical research of the Houdry Process Corporation, Marcus Hook, Pennsylvania, was named secretary.

Lyman has conducted extensive research on the production of synthetic lubricants and is an authority on lubricating oil refining. He was graduated from the University of California.

R. H. McGough has been appointed manager of sulfur products sales for Brea Chemicals, Inc., with offices in the Petroleum Building, 714 West Olympic Boulevard, Los Angeles. McGough has been with the by-products chemical division of Union Oil Company since 1943.

Personals

▸ **Dr. Charles H. Riesz** has joined the staff of Armour Research Foundation of Illinois Institute of Technology, Chicago. He is heading project research in the area of catalysis, for industrial applications. Dr. Riesz came to the Foundation from the Institute of Gas Technology, where he had investigated numerous catalysis applications to the utility gas industry since his appointment in 1941.

Dr. Riesz's previous industrial affiliations were with Universal Oil Products Company, Gulf Research and Development Company, Sinclair Refining Company, and Eastman Kodak Company.

▸ **Fred W. Foushee** has been appointed assistant personnel supervisor and **G. T. Martin** has been named group leader at Standard Oil Company's Whiting, Indiana, research laboratory. Martin is in charge of technical service work on light oils distillation and coking processes.

Foushee joined Standard in 1949 as a chemist. He is a graduate of Elon college in North Carolina. Martin joined the company in 1949 as a chemical engineer. He is an alumnus of Mississippi State college and the University of Louisville.

George Armistead, Jr.

▸ **George Armistead, Jr.**, head of George Armistead and Company, consulting engineers for petroleum and chemical fields, has been appointed a member of the Board of Registration for Professional Engineers, by the District of Columbia Commissioners. Armistead has been active in the petroleum industry for nearly 30 years, and is well known for his engineering work for oil refiners and chemical manufacturers in the development of new projects, and work for financial interests and insurance companies in various phases of the petroleum and chemical industries. He has been active in the safety field and is the author of the book "Safety in Petroleum Refining and Related Industries." Armistead's appointment is for five years during which he will comprise the chemical engineering representative on the Board of Registration as provided under the terms of the Registration Act. The board is charged with assuring proper qualifications within the District of Columbia.

▸ **Francis W. Winn** has been appointed assistant chief process engineer for Catalytic Construction Company. His duties with Catalytic in their Philadelphia office will encompass the three fields engaged in by the company on petroleum, atomic energy, and chemical projects. His responsibilities include research and development, process design and theoretical correlations.

Winn came to Catalytic from the research and development department of the Socony-Vacuum Oil Company where he specialized for five years on process design and economic studies of refinery equipment and developed an exact computation procedure for multicomponent fractionation.

News

A typical SADIC system.

Data Reduction Simplified by New Converter

The SADIC, Consolidated Engineering's new Analog-to Digital converter, completely eliminates the analog plot and directly converts the test measurements from standard pressure pickups, thermocouples, and strain gages to numerical values. These are immediately and automatically typed or printed out on tapes, or they can be punched into standard cards for automatic processing. Not only is the process of data reduction —the conversion of simple measurements to usable engineering information—vastly speeded up, but the possibility of human error is virtually eliminated.

Numerical measurements indicated by SADIC lighted panels and printed on its readout equipment are accurate to within 1 part in 1000. This 1/10th per cent validity is coupled with a speed that allows measurements to be sampled as often as once every second. Thus, any device or structure—motors on test stands, wind-tunnel models, and hydraulic systems for example—which can reach a semi-stabilized condition, can be tested in actual operation. Flexibility of the SADIC Systems allows any number of measurements to be simultaneously converted to digital form. Although each SADIC is used for only one phenomenon, systems of any number of channels may be assembled and expanded at any time. In this way investigations can be simplified.

Husky Oil Plans $1,000,000 Wyoming Refinery Expansion

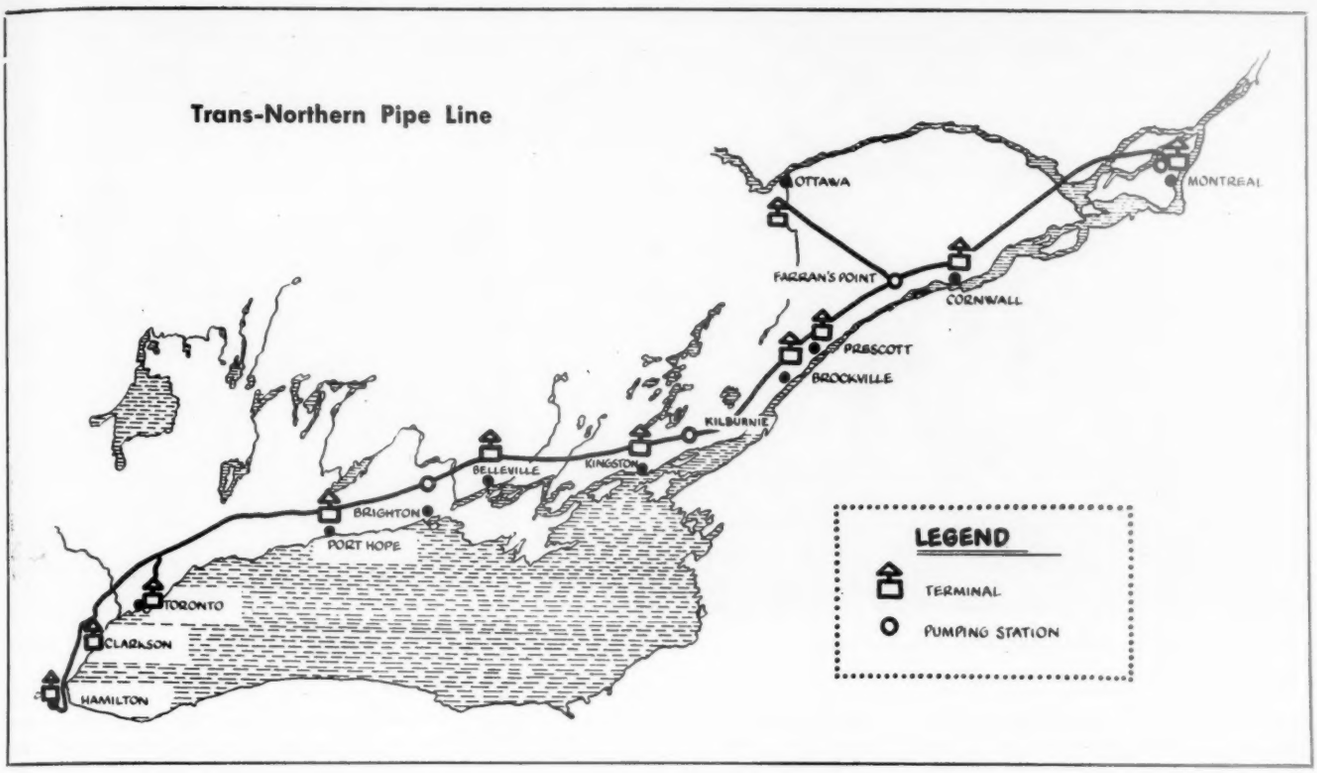
Commencement of a million dollar building program for the Cody, Wyoming, refinery of Husky Oil Company was announced recently by Glenn E. Nielson, president of Husky. The program adopted will increase refining facilities by the addition of an asphalt vacuum unit and a catalytic reforming unit as well as the addition of other equipment and facilities. Completion date has been set for June 1953.

In making the announcement, Nielson stated that Husky had signed a catalyst licensing agreement with the Atlantic Refining Company preparatory to the construction of a 1000 bbl per day reforming unit.

One contract has been signed with the Grebe and Doremus Company, of Houston, Texas, for the construction of the Catforming or naphtha reforming unit. The Koch Engineering Company has been awarded the design contract for the vacuum unit and the Wickes Boiler Company has the assignment for the steam generator. The remaining contracts of the program have not yet been assigned, Husky reports.

Bell to Begin New Expansion Program

Bell Oil and Gas Company has announced plans for a $4,500,000 expansion program, beginning early this year. One project will be the construction of a $1,500,000 coking unit at the Ben Franklin refinery at Ardmore, Oklahoma. The new building program will be carried out in addition to a catalytic cracking unit that is approximately 30 per cent complete.



Canada's Longest Products System

Trans-Northern's 444-mile pipe line, linking the Montreal East refining area with heavy consuming areas, goes into operation

LESLIE O. ROWLAND

THROUGH the industrial heart of Canada, across the thickly settled rich farmland of southern and eastern Ontario, has been constructed in one short season a 10-in. products pipe line that probably will be Canada's largest products line for many years to come. The 444-mile line of Trans-Northern Pipe Line Company, which includes 400 miles of the 10-in. main line and 44 miles of 8-in. branch line serving the Canadian capital city of Ottawa, links the concentrated refinery area of Montreal East in Quebec Province with the heavy consuming regions between Montreal and Hamilton, Ontario. This strip of Canada's most historic land, touching the St. Lawrence River for nearly half the pipe line distance, is one of the world's fastest growing areas, whose consumption of petroleum products in 1952 was approximately 11,000,000 bbl, and is expected to rise to 12,491,000 bbl by 1955.

Such a demand constitutes almost one-tenth of the entire Canadian requirements. In the past the marketing territory has been served by means of railway tank cars the year 'round, supplemented by lake and river tankers during the summer season. The four to five months of winter when the canals are impassable on account of freezing have always been a severe problem for the refiners, which have had to build up fairly large stocks against emergencies arising out of winter transportation problems. The phenomenal growth of the market, combined with the scarcity of transportation media, prompted the decision to build the pipe line.

That is the economic and climatic background for the line, with initial capacity of 40,000 bbl per day, which is designed primarily to provide daily and dependable weather-proof transportation between three Montreal refineries and ten terminals along the route through Toronto to Hamilton. Incidentally, it probably represents a more economical utilization of steel than the same capacity in lake tankers and additional railway tank cars.

Owners are three of the principal refiners: Shell Oil Company of Canada, Ltd., The British American Oil Company, Ltd., and McColl-Frontenac Oil Company, Ltd. Among them they have approximately 70 per cent of the capacity at Montreal (111,000 bbl per day out of 157,000 bbl), which in turn amounts to 40 per cent of Canada's total capacity. The historical accident that established this enormous refining industry on the basis of South American and Middle East crude, at a time when western Canada was hardly in the oil producing business, can be credited to some extent for the construction of the Trans-Northern products pipe line.

Construction of the line occupied three contractors with three full spreads, two specialized river crossing spreads, and one small spread that worked entirely on the island of Montreal on special assignments and refinery tie-ins. The

EXCLUSIVE

Pipe gang lining up two joints with internal clamp.

Welder and helper running hot pass.

general contract was let to Mannix-Williams Brothers Corporation, Ltd., a joint project company organized by Mannix, Ltd., of Calgary, Alberta, and Williams Brothers Corporation (Canada), Ltd, of Edmonton, Alberta. One subcontract was let to Sparling-Davis Company, Ltd., of Edmonton, for a total of 183 miles, all main lines between Hamilton and Kingston with the exception of about 12 miles in and around the city of Toronto, which was laid by Comstock Midwestern, Ltd., as a joint project in the course of its work on the Sarnia Products Pipe Line, which parallels Trans-Northern in the same right-of-way at that point.

The other main line subcontract was let to Williams Brothers Corporation (Canada), Ltd., for a total distance of about 200 miles, and this firm also laid the 44-mile branch to Ottawa. All river crossings, of which there were a dozen major jobs, were put in by the general contractor, with Guy S. Connors of Williams, Connors, Stanfield in Tulsa as a special consultant to plan, inspect, and generally supervise the work.

From kick-off at the end of May, the entire construction period was just a little over four months, with final tie-in welds being completed before the scheduled completion date of October 1. Completion of terminals and pumping stations delayed the start of flow through the line until November 1, still comfortably ahead of the earliest likely date for the freeze-up of waterways.

Construction

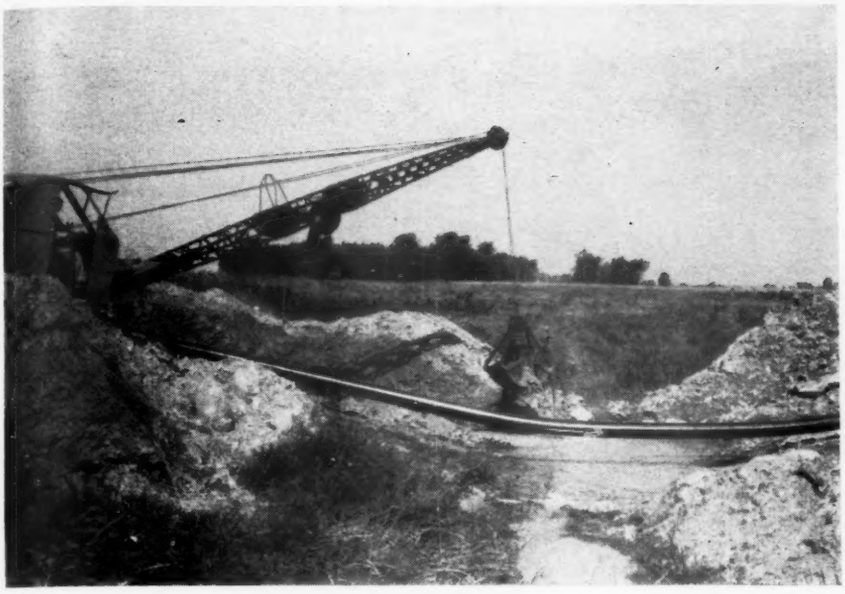
Trans-Northern is the first trunk pipe line to be built in Canada through a region involving such a long distance of thickly populated country, and one of the most difficult ever constructed anywhere for complexity of right-of-way acquisition, according to President A. N. Horne, the tall, taciturn Mississippian who also directed construction of TAPline.

Double-shoe bending tractor making overbend for creek crossing.

The concentrated impact of centuries of land development history could be seen in the cutting of literally thousands of barbed wire fences that cross the pipe line route. This section of Canada was the earliest settled, and historic methods of laying out the farms created long extenuated land holdings running back as far as four miles from the St. Lawrence River and the north shore of Lake Ontario. The dual purpose of giving access to water transportation before roads were cut through the thickly wooded terrain, and affording protection against Indians by placing houses and farm buildings close together along the waterfront, resulted in dozens of holdings to the lateral mile. Later development, with construction of cattle runs and small pasture lots within the boundaries, has left as many as 30 fences to the mile.

As a result, one of the most important units in each spread was the right-of-way crew. This gang, using a medium-weight covered truck, had to cut every fence where it crossed the right-of-way and install a gate. Every gate took three or four light posts, cut from clumps of trees along the route, as well as a few extra yards of barbed wire. As all fences had to be replaced in original condition after cleanup, the cleanup gang had to reverse the work and tie-in the original fence line, so that there was no salvage value in the gate posts. As a matter of public relations, these were generally stacked alongside the right-of-way and donated to the owner of the property.

The other major time-consuming problem was rock shooting, largely concentrated in the region on both sides of Kingston, approximately the half-way point on the main line, at the point where Lake Ontario drains into the St. Lawrence River. Here, the Precambrian basement of igneous rocks outcrops for several miles, interspersed with thin stringers of sedimentary rocks that overlie the basement to increasing depth



Clamming out low spot where creek crosses right-of-way.

both east and west of the Kingston outcrop. About 30 miles of solid rock was encountered on the entire line.

Rock gangs worked two 12-hr shifts, and averaged 1000 to 1200 ft per 24 hr. The deposition of thin soil cover in all shallow places made it necessary to strip 12 to 18 in. of overburden in most parts of the rocky terrain. This was done with backhoes. Shotholes were then drilled to a total depth of 5 ft, providing for 18 in. of cover over the pipe as well as the normal loss of 12 to 14 in. of ditch in the shooting.

Rock drills were mounted tandem fashion, two to each boom, carried by tractors equipped with sidebooms. Power was provided by air compressors of about 500 cu ft capacity.

Sedimentary stringers of limestone did not prove any easier to drill than the Precambrian igneous rocks. Economy of manpower was observed, with three men to each twin-drill on each shift, and one foreman supervising two units. Shot holes were filled with 60 per cent Forcite, by a crew of about eight men, and each section was shot at the end of the afternoon each day. One tractor with angledozer blade cleared the blasted rock off the travelled portion of the right-of-way, and the ditch was cleaned out with backholes. Although most pipe was strung ahead of the rock gang, very little damage occurred from blasting.

All pipe stringing was subcontracted to Canadian Parkhill Pipe Stringing, Ltd., of Toronto, subsidiary of Parkhill Truck Company, Tulsa, Oklahoma. Stringing trucks were bought in Canada. Although in most places the main highways are a mile or more from the right-of-way, because of the layout of farms mentioned above that compelled roads to run north and south rather than east and west, the large number of private farm roads made it easy to gain access from the principal east-west highways. Most of the ground along the route is comparatively level, and the only serious obstacles to travel along the right-of-way were minor creeks and a few stretches of bad swamp. In one swampy interval in the rock country, a few miles west of Kingston, all the machines on the rock gang were buried above their tracks for several hours.

Ditching was done mostly by conventional rotary ditching machines, except for the rock areas. Backhoes were used in the softest swamp regions and were run in for single operations on some of the deeper creek channels that the rotary ditchers could not navigate. Most of the terrain aside from the rock outcrop area is rich, thick soil produced by glacial drift, and makes a beautiful ditch with practically no caving, even in the wet parts. In some areas, the glaciation has left casual boulders at depths varying from a few inches to several feet. Most of these were small enough to be picked up by the rotary ditcher, and the only problem was stripping of teeth on the buckets from striking the boulders. The utility welding gang on each spread generally made bucket teeth repairs on the spot, using pre-cut teeth made from bar steel. A reserve supply was cut and shaped each time the utility gang had any minutes to spare.

Backhoes were moved across the swamps under their own power, using mats of five 6-in. by 8-in. timbers chained together, in groups of half a dozen, which the backhoes picked up from the back and swung ahead as they moved. As the water table was just about on the surface in all the bad swamps, no attempt was made to drain the ditch and pipe was laid in the water. Average distance for ditch cut was about 9000 ft a day, in two 12-hr shifts, and top day

Cleaning and priming machine start on section of pipe.

Coating and wrapping with enamel, glass fiber, and asbestos felt.

on one spread was 2½ miles. Normal depth of ditch was 4 ft, providing 2 ft of cover, and about 90 per cent of the ditch was cut conventionally.

Welding was considered quite satisfactory, and experience with Canadian workers exceeded expectations. Although there has been no chance for Canadians to acquire experience on pipe line welding, because of the newness of pipelining in this country, all helpers hired were local men and the foremen considered that some of them probably would be able to qualify as welders on the next pipe line construction job. The verdict was that they picked up the job quickly and worked perfectly.

Pipe gang operation was conventional, using internal line-up clamps. Equipment consisted of truck-mounted units, two units on a 2-ton truck. Jack Engelking, veteran foreman on one Williams spread, doubled as bending foreman. On this spread a double-shoe bending machine was used for all bends. Every bend was calculated by eye measurement and the machine operator bent the joint on the chalk marks and strung the pipe back in line. The other spreads used conventional center-drum bending machines. Bends were not too frequent, and sometimes the pipe would run several thousand feet without a bend. Creek channels and larger drainage ditches (the latter artificially cut to solve farm drainage problems arising out of low-lying flat ground) generally required a shallow overbend. Side bends were not needed to any great extent.

Welding machines were mounted on four-wheel wagons for the welding gang, set up in line, with the last unit being towed to the front in rotation as each four welds were finished. Objectives for the welding gang was two miles a day, and this was accomplished on most of the line, as weather conditions were good and loss of time due to rain slight. Several days the pipe gang under Jack Engelking made better than 13,000 ft and once set a top record of three miles. On the welding gangs the average number of welds per man per day was about 30, and the rejection rate practically nil. All welding tests were run by Industrial X-Ray Limited of Edmonton, subsidiary of Industrial X-Ray of Tulsa, and staggered checks were made in order to get a fair selection on every welder, at least two or three every day. Quality of the pipe, milled by Page, Hersey and Company, Ltd., in Welland, Ontario, proved good, with only one laminated joint and one split seam disclosed on welding inspection.

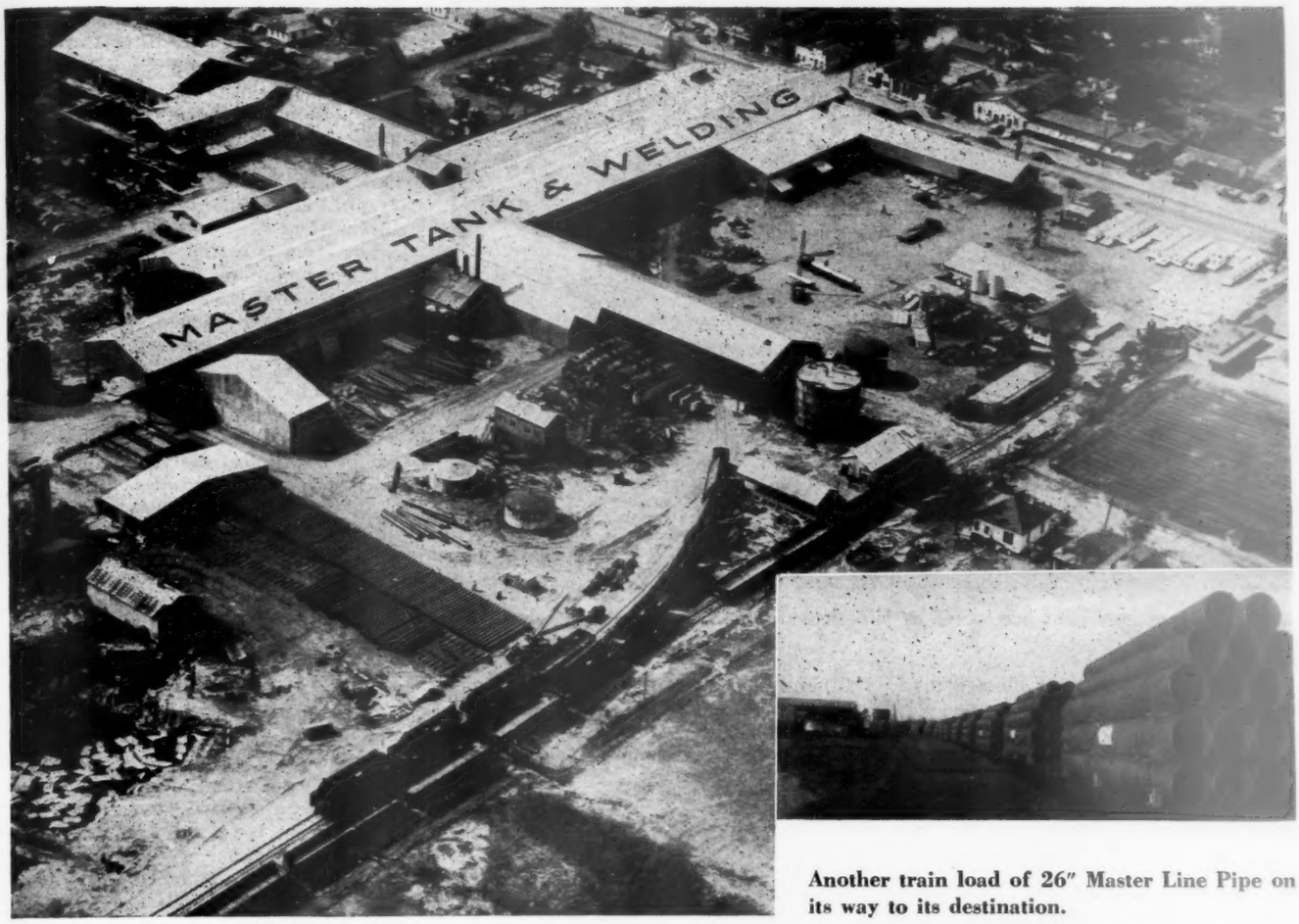
The coating and wrapping operation was conventional, using coal-tar enamel and one wrap of glass fiber followed by an outer wrap of asbestos felt. Application temperature was about 460 F average, and 2500 to 3000 ft was run with each dope pot on the average. Two miles a day was considered a good average, and top distance was about 13,000 ft. Each section was soaped and air-tested before doping.

Pipe was lowered-in directly behind the dope gang. The dope gang tractor carried the pipe directly over the ditch, and a second tractor handled the lowering-in without intermediate skidding. The purpose of this method was to save time and also avoid the usual risk of damage to the outer wrap when pipe is skidded. The absence of many large bends made this method practicable, as well as the omission of slack loops (except at relatively long intervals) in any areas of rolling ground where minor bends could take care of slack requirements. Slack loops were lowered in early in the morning, and generally

Sections of pipe made up for crossing of Lake of Two Mountains at Oka, Quebec.

Placing a pontoon in position to secure it to the pipe.

A line of shot holes, cased with old oilwell casing, for blasting solid rock river bed at Ste. Rose, Quebec.



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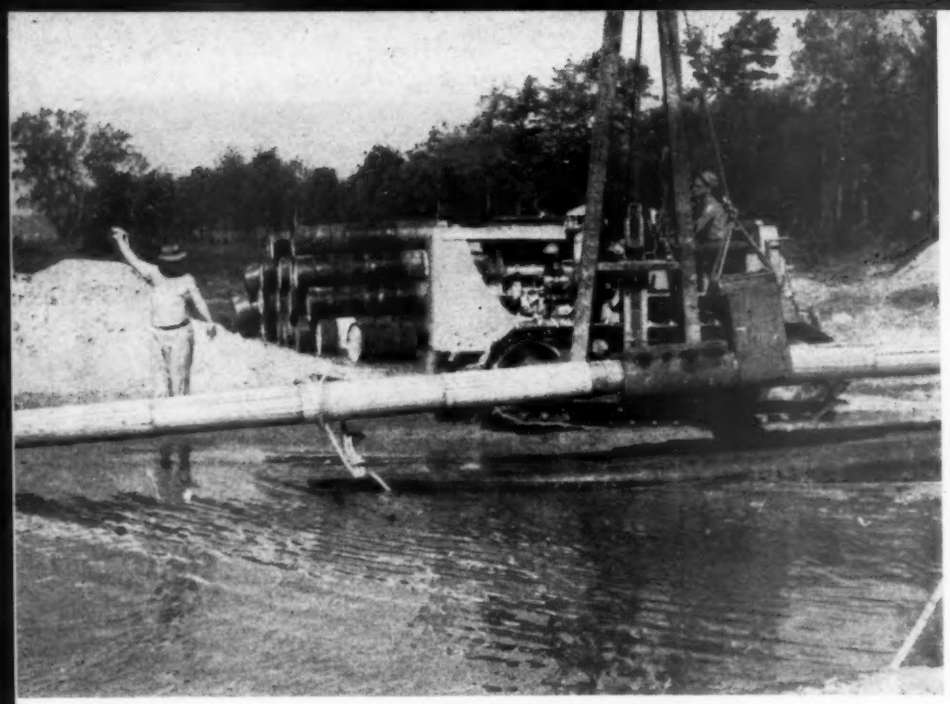


First section of pipe goes into water as Superintendent McCartney directs job.

backfilling was done very close behind the dope and lowering-in gangs.

Tie-ins were few, averaging about one to the mile on straight sections, but with the addition of road and rail crossings the overall average was about three to the mile. The utility gang generally took care of the tie-ins.

Clean-up was complicated by the fact that a large part of the route was through timbered country where woodlots and sugar maple groves had to be respected. Excellent public relations was maintained throughout, valuable sugar maples were left standing in the middle of the right-of-way in many places, and great care was taken by both clearing and clean-up gangs to avoid damaging growing timber off the right-of-way. What might have been a costly item in the construction was disposed of in many cases by paying the landowner a fair sum to complete the clean-up and harrow the ground, and in all cases the cleaned brush was given to the owner for firewood.

Each of the main spreads comprised about 120 men. The Sparling-Davis spread was directed by general superintendent Jack Beaman and spread superintendent E. E. Deaton. The Williams Brothers spreads were managed by assistant general superintendent Claude Lightfoot and spread superintendent Jim Childers, respectively. The small Williams Brothers spread on the island of Montreal was directed by spread superintendent Pat D. Campbell. The river crossing spreads were bossed by superintendents John H. "Fat" McCartney and Jimmy Davidson. Project manager for the entire job was J. E. Richardson.

Water Crossings

Of the eight major river crossings, ranging from 480 to 7250 ft in width, the most interesting was the 7250-ft crossing of the Lake of Two Mountains, actually a wide part of the Ottawa River near its confluence with the St. Lawrence just below Oka, Quebec, a few miles northwest of Montreal. With maximum depth of 51 ft, this crossing is believed to rank with the deepest pipe line crossings on the continent. Most of the operations were conducted from a point on the grounds of the large, centuries-old monastery of the Trappist Fathers, from which laboratory-tested Trappist cheese has almost a world-wide distribution.

The Oka crossing enjoyed perfect weather conditions, and was completed in four days at the end of August, with virtually no disturbance from wind. Pipe strings were made up on the east shore in 16 sections of twelve 40-ft joints each. All sections were doped and wrapped, and encased in an extra outer coat of double tar paper around which was clamped a protective layer of building lath secured by steel tapes. Every weld on the river crossing strings was X-rayed individually.

On account of the good sand bottom in the river, and the relative stability of the water at the maximum depth, the center portion was not ditched. From each side a 10-ft ditch was cut by dredging to the point where water depth was 15 ft. This gave a total of 2250 ft from the east side and 1272 ft from the west.

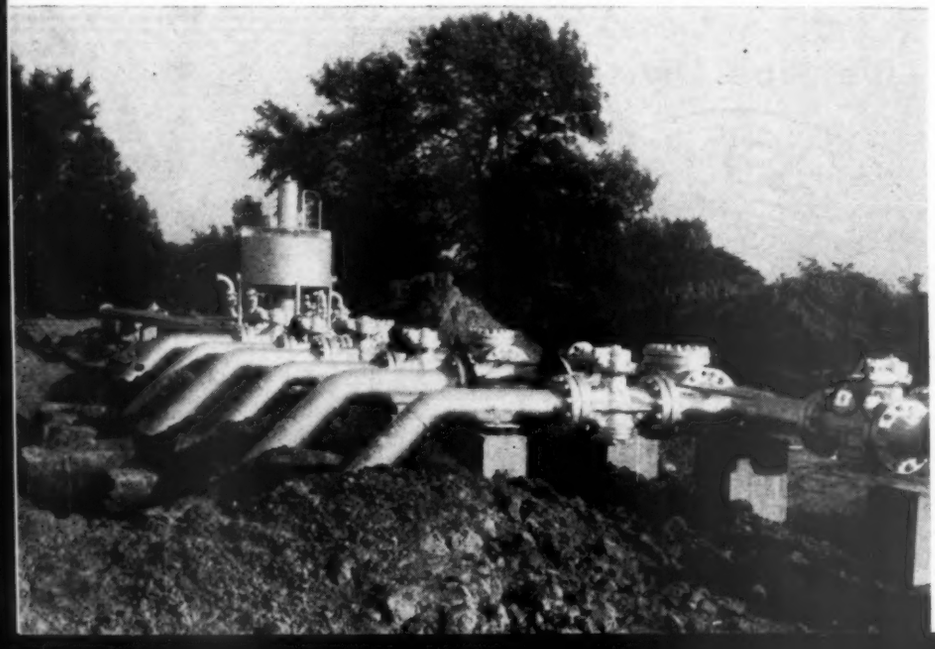
Laying went off very smoothly, from dawn to dusk each day. Long pontoons were made up from 16-in. pipe joints, which were afterward salvaged for use as casing on road and rail crossings. Plugs were welded on each end and the pontoons were attached to the pipe strings at 100-ft intervals, using 1½-in. ropes. These pontoons were engineered to provide negative buoyancy of 8 lb per ft, allowing the pipe to be pushed from the east shore for the first 5000 ft before any pulling would be required. River weights of 500 lb each were clamped on at 50-ft intervals, providing enough weight to allow the pipe to lie snug on the bottom.

Two sideboom tractors, a dragline, and a motor crane were hitched up in tandem for the push, and the first section had been pushed into the water within four hours after the start of pipe laying, including the time required to tie on the pontoons. The first tie-in welds was completed before noon on the first day and this speed was maintained throughout the job. Each successive tie-in weld was made on the shore.

An anchored barge, manufactured on the site by welding heavy steel plates together, was supported by pontoons made of oil drums welded end-to-end, and held in place in the water by concrete blocks reinforced by steel rails. The barge kept a slack line on the front end of the pipe string until the first section was in, then the operation was a combined push and pull for 5000 ft, the barge pulling with a ¾-in. wire line. At that point, the pontoons were discontinued, as well as the barge, and the remaining 2250 ft was pulled from the west shore by a tractor and winch and 2000 ft of 1-in. line.

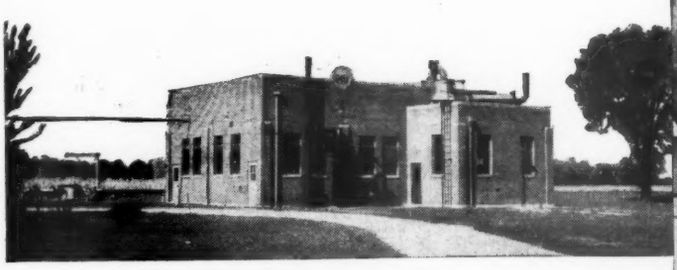
Pontoons were cut off by divers after the pipe was in place, and the dredged material was backfilled to clear the channel. The entire operation was conducted without the use of radio on the

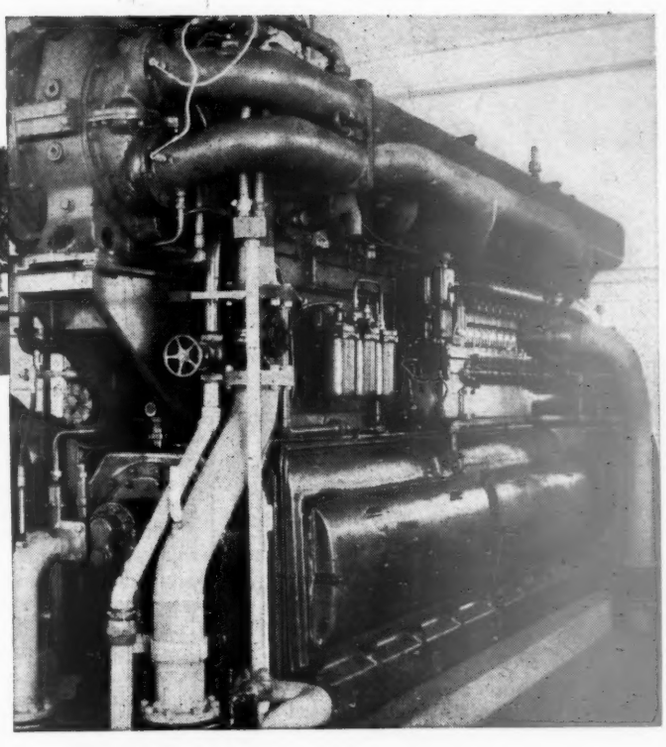
Manifold being installed at the input station, Montreal.



165,000 hours of service completed by 28 Alco Diesels at 98½% availability

for Gulf Refining Company





Twenty-two years ago, Gulf Refining Company installed 28 Alco Diesel Engines on its new, 700-mile Tulsa-to-Spencerville Junction pipeline. Today, those 28 Alco Diesels have completed more than 165,000 hours of service and are operating at 98½% availability. And since 1941, when the output of the line was greatly increased, they have been in actual service an average of 97% of the time.

Pumping station superintendents throughout the United States and Canada specify Alco Standardized Diesels because of this kind of *proved* dependability——and because of these economy features:

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HOT DOPE

Straight from the Kettle on *PIPE PROTECTION*

★

By Boyd Mayes

● An engineer for a major pipe line company asked us recently to give him a few reasons why his company should give us his cleaning, coating and wrapping business. We're glad he asked us because we don't believe he was actually aware of the fact we'd been in business in Houston for more than 25 years; that we have more than a million dollars invested in a plant and equipment to give 24-hour service 365 days in the year; that we have around 80 of the top craftsmen in the business with $12,000.00 to $15,000.00 invested in each of these men who we keep on the payroll whether we need them or not, just to have them ready for his company's call; that we've conditioned more than 300 million feet of pipe ranging in size from ½" to 60"; that little jobs and big jobs get the same fine workmanship at our place; and that, in our more than a quarter of a century of serving the pipe line industry, we've never cheated a customer yet!

MAYES BROS.

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Double tandem rock drill operating in mixed limestone and igneous formation a few miles west of Kingston, Ontario.

job, although superintendent McCartney had two-way radio communication from this pickup to the base station in the adjacent Montreal suburb of St. Eustache where the field office was located.

A different construction method was used on the crossing of Hamilton Bay, at the west end of line, where a triple bend was required because of a peculiar angle of the shore line. The pipe for this crossing was made up in three sections on shore. Two derrick barges and three tugs were anchored in the bay, and each section was floated out, tie-in welds being made on the barges. The first section ran at a 60-deg angle from the north shore for 1750 ft, the second section was placed at a 54-deg side-bend angle from this point for 610 ft, and the third section was laid at a 74-deg side-bend angle from the second for 1850 ft to reach the south shore.

Although this crossing involved static water and a pure sand bottom, it was decided to dredge a ditch for the entire crossing, because of the sharp bends. The center 610 ft were ditched 11 ft deep, and the other portions 5 ft deep. Movement of silt on the bottom is expected to provide natural backfill without the need to fill by dredge.

In the case of several other river crossings of much less width but in solid rock, the contractor mounted cable tool rigs, supplied under subcontract by local water well drilling companies, on barges and drilled shot holes, which were cased with second-hand oil-well casing and shot in a single operation.

Operation of the line, which began on November 1, will be largely conventional with respect to modern technology, but the many automatic features of its operating details are completely new to Canada, as this is the first products line of such large size and with such a large number of take-off points. Precision pumping and continuous control of flow from the dispatching office are the mainsprings of smooth functioning.

Pumping Stations

Four main pumping stations, located at Montreal, Farran's Point, Kilburnie, and Brighton, will handle 40,000 bbl a day initially. Addition of four identical stations will raise capacity to 75,000 bbl a day. All stations are of the same conventional design and construction, built of concrete and brick. They are equipped with electrically driven centrifugal pumps rated at 6300 hp and operating at maximum pressures of 1150 psi. The 10 terminals, spaced about equal distances apart, are owned by the shipping companies and are equipped with high-speed loading racks that can meter delivery of products at rates of 300 to 500 gal per minute. Products are also metered into the line, and delivery of the specific batch going into the line is made at the appropriate terminal.

Control of pressure and turbulence has been made highly effective by instrumentation. Mixing of batches is considered likely to be almost negligible. Rate of flow is controlled by motor-operated valves on pumps and an automatic throttling valve that maintains the pre-set rate.

Montreal station, handling the input from the refineries, is the key station on the line and all others synchronize their pressure and rate of flow with it. Line pressure is to be kept within a narrow range either side of 1000 psi.

Communication between stations and terminals is provided by a teletype system set up by Bell Telephone Company of Canada, and each station also is connected by telephone to the nearest local telephone exchange. Automatic push-button control of input and take-off is provided at Montreal and two terminals, Prescott and Clarkson. ★ ★ ★

It takes MUSCLES in the mud

PIPE laying is rough even under favorable conditions. But when you have to handle extra-heavy pipe through mud and muck, as in the above picture, the extra staying power of the Caterpillar D7 Tractor with MD7 Pipe Layer really pays off. The Cat outfits on this pipeline construction job in Texas are owned by the Oklahoma Contracting Corp. of Dallas.

Built to take the extreme strains of pipe laying and stand the grind of working days on end with little rest, these Caterpillar D7 Diesel Tractors with MD7 Pipe Layers are the units preferred by experienced operators, like A. B. Knipe, welding foreman on this job. He says, "We can always depend on Caterpillar-built machines to pull us through."

Balanced Caterpillar engineering matches power output to the job. Conveniently placed operating controls, separate load and boom line drums and clutches, and a special, long-lived Caterpillar transmission, mean accurate control—and "built-in" safety for the men on the job.

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THE PIPE LINE OUTLOOK

Industry's leaders express optimism for the coming year—See continued growth

THE pipe line industry has a healthy outlook for the coming year in the opinion of its leaders. This applies to crude oil, products, and gas pipe lines. Although there was active construction of crude oil and products lines in 1952, as one individual summarizes the situation, there is a definite need for all pipe line facilities now available, and with consumption steadily on the increase there will be a continuing demand for new pipe line facilities. Many see a particularly active expansion in the nation's products pipe line facilities. There will also be an expansion in gathering systems to fill the added trunk line capacity.

It is estimated that during 1953, $1,570,000,000 will be spent for production, underground storage, and transmission of natural gas. In 1952, $1,000,000,000 went into construction and expansion programs of natural gas pipe line systems. As a further indication of growth, 13,500 miles of gas pipe lines were approved or pending before the Federal Power Commission at the beginning of this year.

The following comments have been received by *The Petroleum Engineer* from a cross-section of the industry's spokesmen.

Frank C. Smith

President, American Gas Association, President, Houston Natural Gas

"The gas industry made many significant advances during 1952. Gas transmission and distribution companies overcame serious obstacles to achieve new records in the number of customers served, in volume of sales of utility gas, and in total revenues from sales of gas during the year.

"In spite of keen competition for steel, for manpower and for investment dollars, the nation's vast system of natural gas transmission lines extended into new territories adding nearly one million new customers to the gas utility mains. The industry spent approximately $1.2 billion dollars last year in expanding present facilities and on new construction. About $1 billion of this total was devoted to the construction and expansion program of the natural gas pipe line systems.

"A tremendous demand for gas services still exists. The American Gas Association estimates that nearly $1.7 billion dollars, an all-time high, will be spent on increasing the gas industry's underground storage capacity. More than 500 billion cubic feet of natural gas will be stored underground next year to help meet the demand expected from the 1,050,000 gas househeating customers who will be added to gas utility lines in the 1953-1954 heating season.

"Construction of more than 5800 miles of natural gas pipe line was authorized by the Federal Power Commission in 1951 and approximately 5000 additional miles were authorized for construction in 1952. Applications for nearly 13,500 miles of additional pipe line were approved or pending before the commission at the end of the year. These additions already completed bring the nation's natural gas pipe line system of gathering, transmission, and distribution lines to a total of about 342,500 miles today.

"The American Gas Association's Statistical Bureau has estimated that more than $5.6 billion would be spent by the gas industry in the five-year period 1952 through 1956 for new construction and expansion of its present plant. Some shortages of steel and delays in obtaining necessary certificates from the FPC acted as a brake on construction expenditures, which totaled about $1,170,000,000 in 1952, compared with a record peak of $1,461,500,000 spent in 1951; however, it is believed that construction expenditures in 1953 will climb to an all-time high level of $1,680,000,000 unless some drastic change occurs in the national economy.

"The bulk of construction expenditures next year will be devoted to the natural gas branch of the industry, following the pattern of the past few years. An estimated $1.57 billion will be devoted in 1953 to expansion of production, transmission, and underground storage facilities for natural gas.

"While several large transmission lines are planned, surveys made by AGA indicate that an important segment of the industry's expanded capacity will be achieved through increasing the horsepower capacity of compressor stations, by looping present transmission lines, and other measures utilized to conserve materials and to reduce expansion costs.

"Although the gas industry faces many challenges, its prospects for establishing new records in 1953 are most favorable. Natural gas lines will extend into new territories and new customers will be added to gas utility lines. New reserves of natural gas are being discovered. With some of the threat of further federal encroachment eliminated with the change in administration, exploration and wildcatting should accelerate. Economists believe the nation has reached the peak of its war production, so more materials should be available for the gas industry's aggressive construction program next year."

Millard K. Neptune

President, Platte Pipe Line Company

"The outlook for the pipe line industry in 1953 is good—rosy. Business is entering the new year with an outlook of economic prosperity and political understanding. There will be no great decrease in the influence of government on business; however, the profit motive will be recognized, not as a sinister device, but as an implement to build an even higher standard of living. Pipe lines will contribute further toward reducing end use costs and, hence, toward this higher standard of living.

"The year 1953 should be particularly good for the Rocky Mountain region. It will be the first full year of operation of the Platte Pipe Line, and the year should see the installation of a number of small pipe line projects for the purpose of connecting new areas to the Platte line. The high rate of exploration and development which has already resulted from the simple assurance that a pipe line would be built will be further augmented now that revenues are coming in from oil sales."

Harold Decker

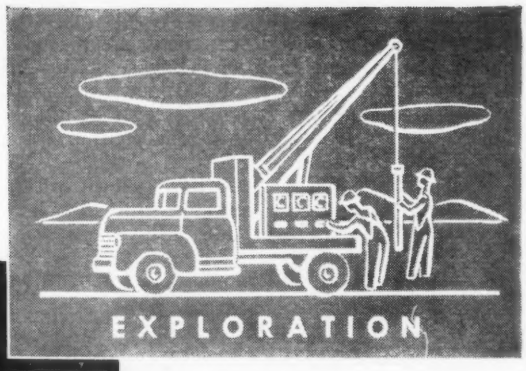
President, Houston Pipe Line Company

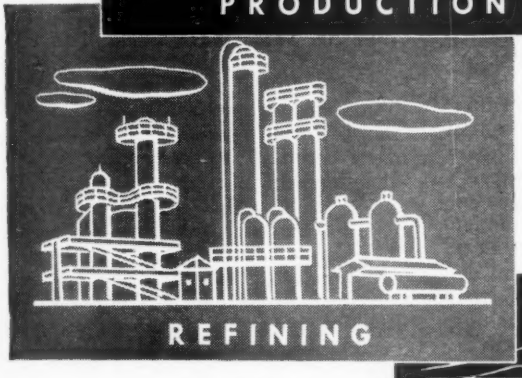
"In the Texas Gulf Coast where all of the operations of Houston Pipe Line Company are situated, we are looking forward to a continued growth in natural gas demand. New industries are coming into the area and already established plants are being expanded thus causing a constant increase in industrial natural gas needs both for fuel and a raw material. As the population of the area grows, home consumption of natural gas is correspondingly on the rise. We expect the rate of growth which has been established in the past few years to continue without let-up through 1953."

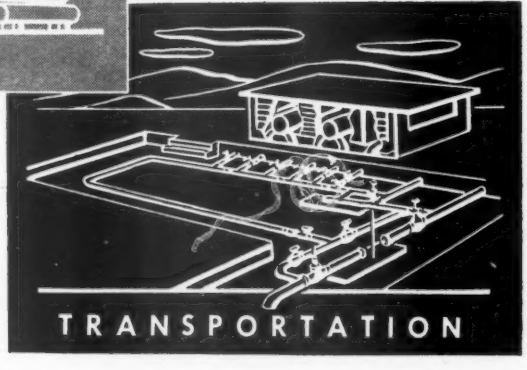
T. S. Johnston

President, Interprovincial Pipe Line Company

"1952 has been a very successful year for us in Interprovincial. We were able to put our 5 new stations in the line and complete a 100-mile loop as well as construction of additional tankage at Superior. Our annual throughputs increased by over 11,000,000 bbl during







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Personals

Dr. Charles H. Riesz has joined the staff of Armour Research Foundation of Illinois Institute of Technology, Chicago. He is heading project research in the area of catalysis, for industrial applications. Dr. Riesz came to the Foundation from the Institute of Gas Technology, where he had investigated numerous catalysis applications to the utility gas industry since his appointment in 1941.

Dr. Riesz's previous industrial affiliations were with Universal Oil Products Company, Gulf Research and Development Company, Sinclair Refining Company, and Eastman Kodak Company.

Fred W. Foushee has been appointed assistant personnel supervisor and **G. T. Martin** has been named group leader at Standard Oil Company's Whiting, Indiana, research laboratory. Martin is in charge of technical service work on light oils distillation and coking processes.

Foushee joined Standard in 1949 as a chemist. He is a graduate of Elon college in North Carolina. Martin joined the company in 1949 as a chemical engineer. He is an alumnus of Mississippi State college and the University of Louisville.

George Armistead, Jr.

George Armistead, Jr., head of George Armistead and Company, consulting engineers for petroleum and chemical fields, has been appointed a member of the Board of Registration for Professional Engineers, by the District of Columbia Commissioners. Armistead has been active in the petroleum industry for nearly 30 years, and is well known for his engineering work for oil refiners and chemical manufacturers in the development of new projects, and work for financial interests and insurance companies in various phases of the petroleum and chemical industries. He has been active in the safety field and is the author of the book "Safety in Petroleum Refining and Related Industries." Armistead's appointment is for five years during which he will comprise the chemical engineering representative on the Board of Registration as provided under the terms of the Registration Act. The board is charged with assuring proper qualifications within the District of Columbia.

Francis W. Winn has been appointed assistant chief process engineer for Catalytic Construction Company. His duties with Catalytic in their Philadelphia office will encompass the three fields engaged in by the company on petroleum, atomic energy, and chemical projects. His responsibilities include research and development, process design and theoretical correlations.

Winn came to Catalytic from the research and development department of the Socony-Vacuum Oil Company where he specialized for five years on process design and economic studies of refinery equipment and developed an exact computation procedure for multicomponent fractionation.

News

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The SADIC, Consolidated Engineering's new Analog-to Digital converter, completely eliminates the analog plot and directly converts the test measurements from standard pressure pickups, thermocouples, and strain gages to numerical values. These are immediately and automatically typed or printed out on tapes, or they can be punched into standard cards for automatic processing. Not only is the process of data reduction —the conversion of simple measurements to usable engineering information—vastly speeded up, but the possibility of human error is virtually eliminated.

Numerical measurements indicated by SADIC lighted panels and printed on its readout equipment are accurate to within 1 part in 1000. This 1/10th per cent validity is coupled with a speed that allows measurements to be sampled as often as once every second. Thus, any device or structure—motors on test stands, wind-tunnel models, and hydraulic systems for example—which can reach a semi-stabilized condition, can be tested in actual operation. Flexibility of the SADIC Systems allows any number of measurements to be simultaneously converted to digital form. Although each SADIC is used for only one phenomenon, systems of any number of channels may be assembled and expanded at any time. In this way investigations can be simplified.

Husky Oil Plans $1,000,000 Wyoming Refinery Expansion

Commencement of a million dollar building program for the Cody, Wyoming, refinery of Husky Oil Company was announced recently by Glenn E. Nielson, president of Husky. The program adopted will increase refining facilities by the addition of an asphalt vacuum unit and a catalytic reforming unit as well as the addition of other equipment and facilities. Completion date has been set for June 1953.

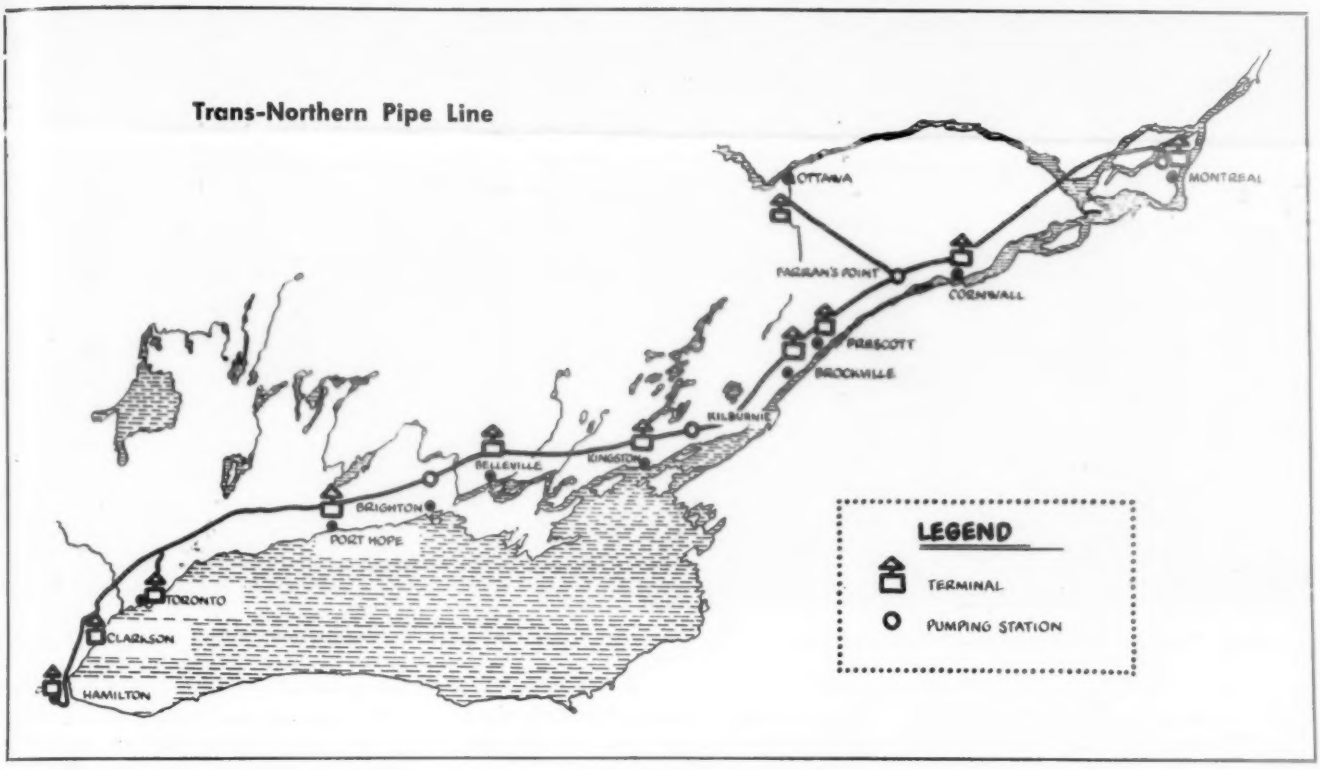
In making the announcement, Nielson stated that Husky had signed a catalyst licensing agreement with the Atlantic Refining Company preparatory to the construction of a 1000 bbl per day reforming unit.

One contract has been signed with the Grebe and Doremus Company, of Houston, Texas, for the construction of the Catforming or naphtha reforming unit. The Koch Engineering Company has been awarded the design contract for the vacuum unit and the Wickes Boiler Company has the assignment for the steam generator. The remaining contracts of the program have not yet been assigned, Husky reports.

Bell to Begin New Expansion Program

Bell Oil and Gas Company has announced plans for a $4,500,000 expansion program, beginning early this year. One project will be the construction of a $1,500,000 coking unit at the Ben Franklin refinery at Ardmore, Oklahoma. The new building program will be carried out in addition to a catalytic cracking unit that is approximately 30 per cent complete.

XUM



Canada's Longest Products System

Trans-Northern's 444-mile pipe line, linking the Montreal East refining area with heavy consuming areas, goes into operation

LESLIE O. ROWLAND

THROUGH the industrial heart of Canada, across the thickly settled rich farmland of southern and eastern Ontario, has been constructed in one short season a 10-in. products pipe line that probably will be Canada's largest products line for many years to come. The 444-mile line of Trans-Northern Pipe Line Company, which includes 400 miles of the 10-in. main line and 44 miles of 8-in. branch line serving the Canadian capital city of Ottawa, links the concentrated refinery area of Montreal East in Quebec Province with the heavy consuming regions between Montreal and Hamilton, Ontario. This strip of Canada's most historic land, touching the St. Lawrence River for nearly half the pipe line distance, is one of the world's fastest growing areas, whose consumption of petroleum products in 1952 was approximately 11,000,000 bbl, and is expected to rise to 12,491,000 bbl by 1955.

Such a demand constitutes almost one-tenth of the entire Canadian requirements. In the past the marketing territory has been served by means of railway tank cars the year 'round, supplemented by lake and river tankers during the summer season. The four to five months of winter when the canals are impassable on account of freezing have always been a severe problem for the refiners, which have had to build up fairly large stocks against emergencies arising out of winter transportation problems. The phenomenal growth of the market, combined with the scarcity of transportation media, prompted the decision to build the pipe line.

That is the economic and climatic background for the line, with initial capacity of 40,000 bbl per day, which is designed primarily to provide daily and dependable weather-proof transportation between three Montreal refineries and ten terminals along the route through Toronto to Hamilton. Incidentally, it probably represents a more economical utilization of steel than the same capacity in lake tankers and additional railway tank cars.

EXCLUSIVE

Owners are three of the principal refiners: Shell Oil Company of Canada, Ltd., The British American Oil Company, Ltd., and McColl-Frontenac Oil Company, Ltd. Among them they have approximately 70 per cent of the capacity at Montreal (111,000 bbl per day out of 157,000 bbl), which in turn amounts to 40 per cent of Canada's total capacity. The historical accident that established this enormous refining industry on the basis of South American and Middle East crude, at a time when western Canada was hardly in the oil producing business, can be credited to some extent for the construction of the Trans-Northern products pipe line.

Construction of the line occupied three contractors with three full spreads, two specialized river crossing spreads, and one small spread that worked entirely on the island of Montreal on special assignments and refinery tie-ins. The

Pipe gang lining up two joints with internal clamp.

Welder and helper running hot pass.

general contract was let to Mannix-Williams Brothers Corporation, Ltd., a joint project company organized by Mannix, Ltd., of Calgary, Alberta, and Williams Brothers Corporation (Canada), Ltd, of Edmonton, Alberta. One subcontract was let to Sparling-Davis Company, Ltd., of Edmonton, for a total of 183 miles, all main lines between Hamilton and Kingston with the exception of about 12 miles in and around the city of Toronto, which was laid by Comstock Midwestern, Ltd., as a joint project in the course of its work on the Sarnia Products Pipe Line, which parallels Trans-Northern in the same right-of-way at that point.

The other main line subcontract was let to Williams Brothers Corporation (Canada), Ltd., for a total distance of about 200 miles, and this firm also laid the 44-mile branch to Ottawa. All river crossings, of which there were a dozen major jobs, were put in by the general contractor, with Guy S. Connors of Williams, Connors, Stanfield in Tulsa as a special consultant to plan, inspect, and generally supervise the work.

From kick-off at the end of May, the entire construction period was just a little over four months, with final tie-in welds being completed before the scheduled completion date of October 1. Completion of terminals and pumping stations delayed the start of flow through the line until November 1, still comfortably ahead of the earliest likely date for the freeze-up of waterways.

Construction

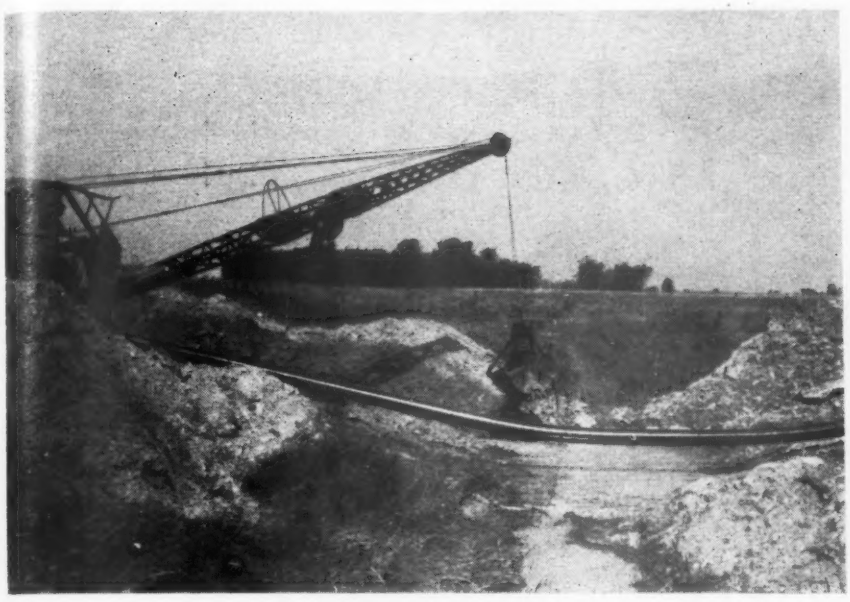
Trans-Northern is the first trunk pipe line to be built in Canada through a region involving such a long distance of thickly populated country, and one of the most difficult ever constructed anywhere for complexity of right-of-way acquisition, according to President A. N. Horne, the tall, taciturn Mississippian who also directed construction of TAPline.

Double-shoe bending tractor making overbend for creek crossing.

The concentrated impact of centuries of land development history could be seen in the cutting of literally thousands of barbed wire fences that cross the pipe line route. This section of Canada was the earliest settled, and historic methods of laying out the farms created long extenuated land holdings running back as far as four miles from the St. Lawrence River and the north shore of Lake Ontario. The dual purpose of giving access to water transportation before roads were cut through the thickly wooded terrain, and affording protection against Indians by placing houses and farm buildings close together along the waterfront, resulted in dozens of holdings to the lateral mile. Later development, with construction of cattle runs and small pasture lots within the boundaries, has left as many as 30 fences to the mile.

As a result, one of the most important units in each spread was the right-of-way crew. This gang, using a medium-weight covered truck, had to cut every fence where it crossed the right-of-way and install a gate. Every gate took three or four light posts, cut from clumps of trees along the route, as well as a few extra yards of barbed wire. As all fences had to be replaced in original condition after cleanup, the cleanup gang had to reverse the work and tie-in the original fence line, so that there was no salvage value in the gate posts. As a matter of public relations, these were generally stacked alongside the right-of-way and donated to the owner of the property.

The other major time-consuming problem was rock shooting, largely concentrated in the region on both sides of Kingston, approximately the half-way point on the main line, at the point where Lake Ontario drains into the St. Lawrence River. Here, the Precambrian basement of igneous rocks outcrops for several miles, interspersed with thin stringers of sedimentary rocks that overlie the basement to increasing depth



Clamming out low spot where creek crosses right-of-way.

both east and west of the Kingston outcrop. About 30 miles of solid rock was encountered on the entire line.

Rock gangs worked two 12-hr shifts, and averaged 1000 to 1200 ft per 24 hr. The deposition of thin soil cover in all shallow places made it necessary to strip 12 to 18 in. of overburden in most parts of the rocky terrain. This was done with backhoes. Shotholes were then drilled to a total depth of 5 ft, providing for 18 in. of cover over the pipe as well as the normal loss of 12 to 14 in. of ditch in the shooting.

Rock drills were mounted tandem fashion, two to each boom, carried by tractors equipped with sidebooms. Power was provided by air compressors of about 500 cu ft capacity.

Sedimentary stringers of limestone did not prove any easier to drill than the Precambrian igneous rocks. Economy of manpower was observed, with three men to each twin-drill on each shift, and one foreman supervising two units. Shot holes were filled with 60 per cent Forcite, by a crew of about eight men, and each section was shot at the end of the afternoon each day. One tractor with angledozer blade cleared the blasted rock off the travelled portion of the right-of-way, and the ditch was cleaned out with backholes. Although most pipe was strung ahead of the rock gang, very little damage occurred from blasting.

All pipe stringing was subcontracted to Canadian Parkhill Pipe Stringing, Ltd., of Toronto, subsidiary of Parkhill Truck Company, Tulsa, Oklahoma. Stringing trucks were bought in Canada. Although in most places the main highways are a mile or more from the right-of-way, because of the layout of farms mentioned above that compelled roads to run north and south rather than east and west, the large number of private farm roads made it easy to gain access from the principal east-west highways. Most of the ground along the route is comparatively level, and the only serious obstacles to travel along the right-of-way were minor creeks and a few stretches of bad swamp. In one swampy interval in the rock country, a few miles west of Kingston, all the machines on the rock gang were buried above their tracks for several hours.

Ditching was done mostly by conventional rotary ditching machines, except for the rock areas. Backhoes were used in the softest swamp regions and were run in for single operations on some of the deeper creek channels that the rotary ditchers could not navigate. Most of the terrain aside from the rock outcrop area is rich, thick soil produced by glacial drift, and makes a beautiful ditch with practically no caving, even in the wet parts. In some areas, the glaciation has left casual boulders at depths varying from a few inches to several feet. Most of these were small enough to be picked up by the rotary ditcher, and the only problem was stripping of teeth on the buckets from striking the boulders. The utility welding gang on each spread generally made bucket teeth repairs on the spot, using pre-cut teeth made from bar steel. A reserve supply was cut and shaped each time the utility gang had any minutes to spare.

Backhoes were moved across the swamps under their own power, using mats of five 6-in. by 8-in. timbers chained together, in groups of half a dozen, which the backhoes picked up from the back and swung ahead as they moved. As the water table was just about on the surface in all the bad swamps, no attempt was made to drain the ditch and pipe was laid in the water. Average distance for ditch cut was about 9000 ft a day, in two 12-hr shifts, and top day

Cleaning and priming machine start on section of pipe.

Coating and wrapping with enamel, glass fiber, and asbestos felt.

on one spread was 2½ miles. Normal depth of ditch was 4 ft, providing 2 ft of cover, and about 90 per cent of the ditch was cut conventionally.

Welding was considered quite satisfactory, and experience with Canadian workers exceeded expectations. Although there has been no chance for Canadians to acquire experience on pipe line welding, because of the newness of pipelining in this country, all helpers hired were local men and the foremen considered that some of them probably would be able to qualify as welders on the next pipe line construction job. The verdict was that they picked up the job quickly and worked perfectly.

Pipe gang operation was conventional, using internal line-up clamps. Equipment consisted of truck-mounted units, two units on a 2-ton truck. Jack Engelking, veteran foreman on one Williams spread, doubled as bending foreman. On this spread a double-shoe bending machine was used for all bends. Every bend was calculated by eye measurement and the machine operator bent the joint on the chalk marks and strung the pipe back in line. The other spreads used conventional center-drum bending machines. Bends were not too frequent, and sometimes the pipe would run several thousand feet without a bend. Creek channels and larger drainage ditches (the latter artificially cut to solve farm drainage problems arising out of low-lying flat ground) generally required a shallow overbend. Side bends were not needed to any great extent.

Welding machines were mounted on four-wheel wagons for the welding gang, set up in line, with the last unit being towed to the front in rotation as each four welds were finished. Objectives for the welding gang was two miles a day, and this was accomplished on most of the line, as weather conditions were good and loss of time due to rain slight. Several days the pipe gang under Jack Engelking made better than 13,000 ft and once set a top record of three miles. On the welding gangs the average number of welds per man per day was about 30, and the rejection rate practically nil. All welding tests were run by Industrial X-Ray Limited of Edmonton, subsidiary of Industrial X-Ray of Tulsa, and staggered checks were made in order to get a fair selection on every welder, at least two or three every day. Quality of the pipe, milled by Page, Hersey and Company, Ltd., in Welland, Ontario, proved good, with only one laminated joint and one split seam disclosed on welding inspection.

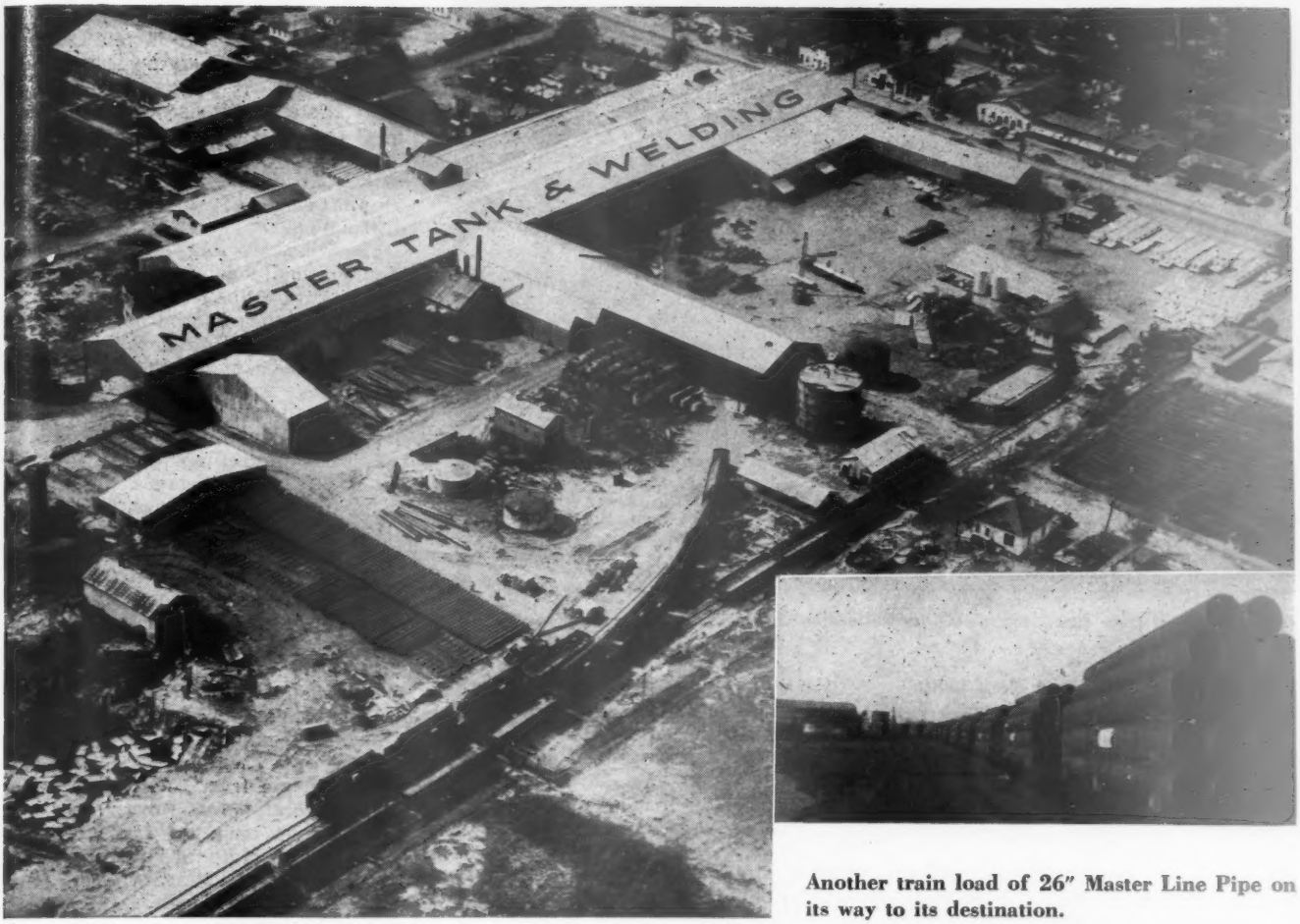
The coating and wrapping operation was conventional, using coal-tar enamel and one wrap of glass fiber followed by an outer wrap of asbestos felt. Application temperature was about 460 F average, and 2500 to 3000 ft was run with each dope pot on the average. Two miles a day was considered a good average, and top distance was about 13,000 ft. Each section was soaped and air-tested before doping.

Pipe was lowered-in directly behind the dope gang. The dope gang tractor carried the pipe directly over the ditch, and a second tractor handled the lowering-in without intermediate skidding. The purpose of this method was to save time and also avoid the usual risk of damage to the outer wrap when pipe is skidded. The absence of many large bends made this method practicable, as well as the omission of slack loops (except at relatively long intervals) in any areas of rolling ground where minor bends could take care of slack requirements. Slack loops were lowered in early in the morning, and generally

Sections of pipe made up for crossing of Lake of Two Mountains at Oka, Quebec.

Placing a pontoon in position to secure it to the pipe.

A line of shot holes, cased with old oilwell casing, for blasting solid rock river bed at Ste. Rose, Quebec.



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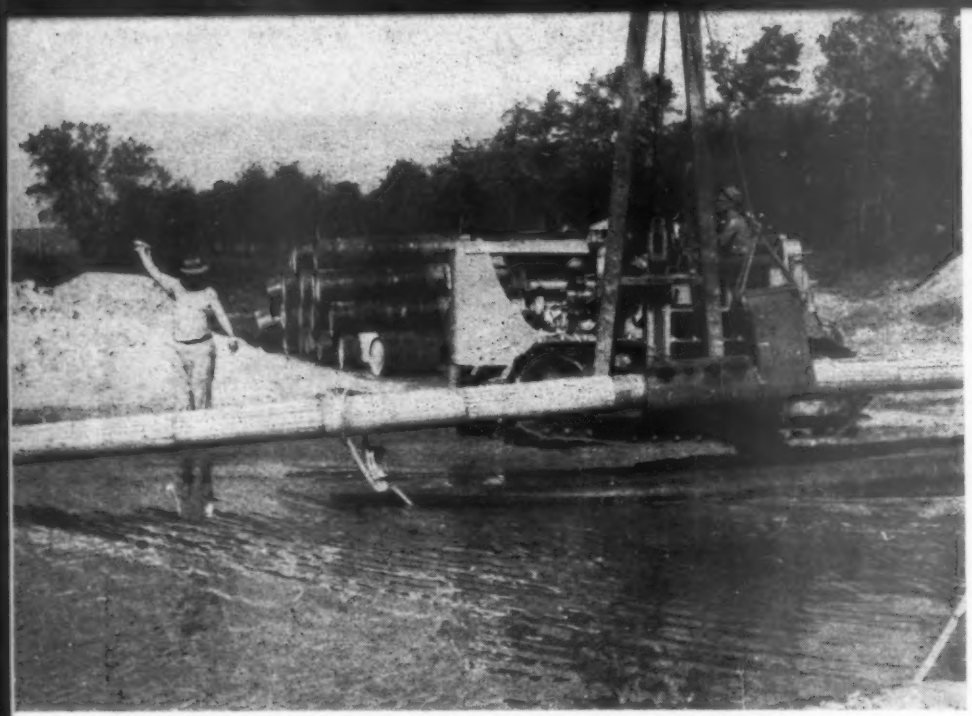


First section of pipe goes into water as Superintendent McCartney directs job.

backfilling was done very close behind the dope and lowering-in gangs.

Tie-ins were few, averaging about one to the mile on straight sections, but with the addition of road and rail crossings the overall average was about three to the mile. The utility gang generally took care of the tie-ins.

Clean-up was complicated by the fact that a large part of the route was through timbered country where woodlots and sugar maple groves had to be respected. Excellent public relations was maintained throughout, valuable sugar maples were left standing in the middle of the right-of-way in many places, and great care was taken by both clearing and clean-up gangs to avoid damaging growing timber off the right-of-way. What might have been a costly item in the construction was disposed of in many cases by paying the landowner a fair sum to complete the clean-up and harrow the ground, and in all cases the cleaned brush was given to the owner for firewood.

Each of the main spreads comprised about 120 men. The Sparling-Davis spread was directed by general superintendent Jack Beaman and spread superintendent E. E. Deaton. The Williams Brothers spreads were managed by assistant general superintendent Claude Lightfoot and spread superintendent Jim Childers, respectively. The small Williams Brothers spread on the island of Montreal was directed by spread superintendent Pat D. Campbell. The river crossing spreads were bossed by superintendents John H. "Fat" McCartney and Jimmy Davidson. Project manager for the entire job was J. E. Richardson.

Water Crossings

Of the eight major river crossings, ranging from 480 to 7250 ft in width, the most interesting was the 7250-ft crossing of the Lake of Two Mountains, actually a wide part of the Ottawa River near its confluence with the St. Lawrence just below Oka, Quebec, a few miles northwest of Montreal. With maximum depth of 51 ft, this crossing is believed to rank with the deepest pipe line crossings on the continent. Most of the operations were conducted from a point on the grounds of the large, centuries-old monastery of the Trappist Fathers, from which laboratory-tested Trappist cheese has almost a world-wide distribution.

The Oka crossing enjoyed perfect weather conditions, and was completed in four days at the end of August, with virtually no disturbance from wind. Pipe strings were made up on the east shore in 16 sections of twelve 40-ft joints each. All sections were doped and wrapped, and encased in an extra outer coat of double tar paper around which was clamped a protective layer of building lath secured by steel tapes. Every weld on the river crossing strings was X-rayed individually.

On account of the good sand bottom in the river, and the relative stability of the water at the maximum depth, the center portion was not ditched. From each side a 10-ft ditch was cut by dredging to the point where water depth was 15 ft. This gave a total of 2250 ft from the east side and 1272 ft from the west.

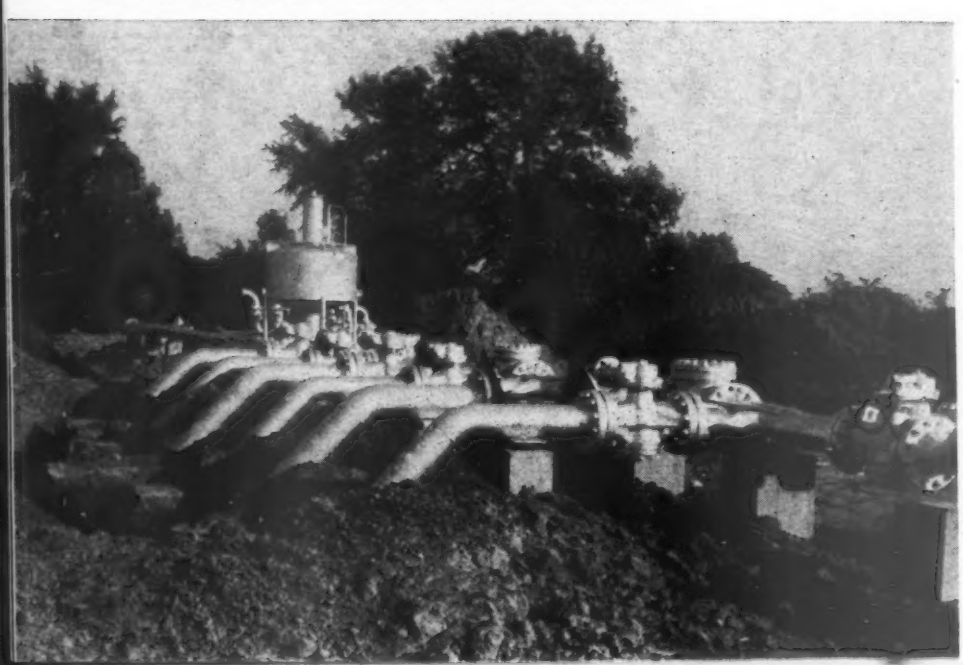
Laying went off very smoothly, from dawn to dusk each day. Long pontoons were made up from 16-in. pipe joints, which were afterward salvaged for use as casing on road and rail crossings. Plugs were welded on each end and the pontoons were attached to the pipe strings at 100-ft intervals, using 1½-in. ropes. These pontoons were engineered to provide negative buoyancy of 8 lb per ft, allowing the pipe to be pushed from the east shore for the first 5000 ft before any pulling would be required. River weights of 500 lb each were clamped on at 50-ft intervals, providing enough weight to allow the pipe to lie snug on the bottom.

Two sideboom tractors, a dragline, and a motor crane were hitched up in tandem for the push, and the first section had been pushed into the water within four hours after the start of pipe laying, including the time required to tie on the pontoons. The first tie-in welds was completed before noon on the first day and this speed was maintained throughout the job. Each successive tie-in weld was made on the shore.

An anchored barge, manufactured on the site by welding heavy steel plates together, was supported by pontoons made of oil drums welded end-to-end, and held in place in the water by concrete blocks reinforced by steel rails. The barge kept a slack line on the front end of the pipe string until the first section was in, then the operation was a combined push and pull for 5000 ft, the barge pulling with a ¾-in. wire line. At that point, the pontoons were discontinued, as well as the barge, and the remaining 2250 ft was pulled from the west shore by a tractor and winch and 2000 ft of 1-in. line.

Pontoons were cut off by divers after the pipe was in place, and the dredged material was backfilled to clear the channel. The entire operation was conducted without the use of radio on the

Manifold being installed at the input station, Montreal.



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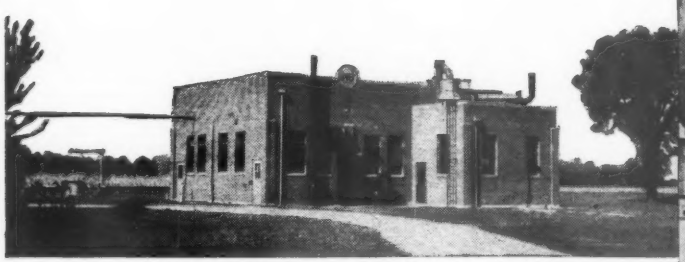

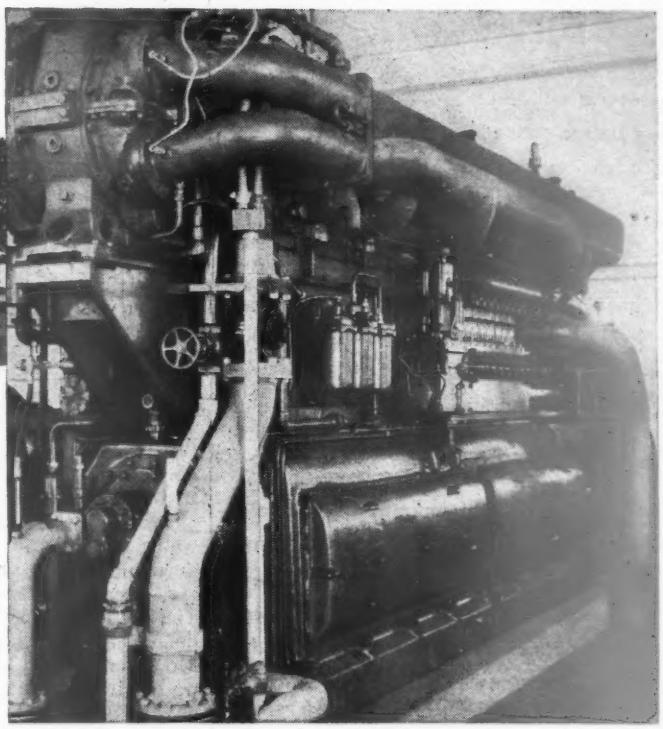

Twenty-two years ago, Gulf Refining Company installed 28 Alco Diesel Engines on its new, 700-mile Tulsa-to-Spencerville Junction pipeline. Today, those 28 Alco Diesels have completed more than 165,000 hours of service and are operating at 98½% availability. And since 1941, when the output of the line was greatly increased, they have been in actual service an average of 97% of the time.

Pumping station superintendents throughout the United States and Canada specify Alco Standardized Diesels because of this kind of *proved* dependability——and because of these economy features:

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HOT DOPE

Straight from the Kettle on *PIPE PROTECTION*

★

By Boyd Mayes

● An engineer for a major pipe line company asked us recently to give him a few reasons why his company should give us his cleaning, coating and wrapping business. We're glad he asked us because we don't believe he was actually aware of the fact we'd been in business in Houston for more than 25 years; that we have more than a million dollars invested in a plant and equipment to give 24-hour service 365 days in the year; that we have around 80 of the top craftsmen in the business with $12,000.00 to $15,000.00 invested in each of these men who we keep on the payroll whether we need them or not, just to have them ready for his company's call; that we've conditioned more than 300 million feet of pipe ranging in size from ½" to 60"; that little jobs and big jobs get the same fine workmanship at our place; and that, in our more than a quarter of a century of serving the pipe line industry, we've never cheated a customer yet!

MAYES BROS.

1130 McCarty HOUSTON, TEXAS ORchard 7566

Double tandem rock drill operating in mixed limestone and igneous formation a few miles west of Kingston, Ontario.

job, although superintendent McCartney had two-way radio communication from this pickup to the base station in the adjacent Montreal suburb of St. Eustache where the field office was located.

A different construction method was used on the crossing of Hamilton Bay, at the west end of line, where a triple bend was required because of a peculiar angle of the shore line. The pipe for this crossing was made up in three sections on shore. Two derrick barges and three tugs were anchored in the bay, and each section was floated out, tie-in welds being made on the barges. The first section ran at a 60-deg angle from the north shore for 1750 ft, the second section was placed at a 54-deg side-bend angle from this point for 610 ft, and the third section was laid at a 74-deg side-bend angle from the second for 1850 ft to reach the south shore.

Although this crossing involved static water and a pure sand bottom, it was decided to dredge a ditch for the entire crossing, because of the sharp bends. The center 610 ft were ditched 11 ft deep, and the other portions 5 ft deep. Movement of silt on the bottom is expected to provide natural backfill without the need to fill by dredge.

In the case of several other river crossings of much less width but in solid rock, the contractor mounted cable tool rigs, supplied under subcontract by local water well drilling companies, on barges and drilled shot holes, which were cased with second-hand oil-well casing and shot in a single operation.

Operation of the line, which began on November 1, will be largely conventional with respect to modern technology, but the many automatic features of its operating details are completely new to Canada, as this is the first products line of such large size and with such a large number of take-off points. Precision pumping and continuous control of flow from the dispatching office are the mainsprings of smooth functioning.

Pumping Stations

Four main pumping stations, located at Montreal, Farran's Point, Kilburnie, and Brighton, will handle 40,000 bbl a day initially. Addition of four identical stations will raise capacity to 75,000 bbl a day. All stations are of the same conventional design and construction, built of concrete and brick. They are equipped with electrically driven centrifugal pumps rated at 6300 hp and operating at maximum pressures of 1150 psi. The 10 terminals, spaced about equal distances apart, are owned by the shipping companies and are equipped with high-speed loading racks that can meter delivery of products at rates of 300 to 500 gal per minute. Products are also metered into the line, and delivery of the specific batch going into the line is made at the appropriate terminal.

Control of pressure and turbulence has been made highly effective by instrumentation. Mixing of batches is considered likely to be almost negligible. Rate of flow is controlled by motor-operated valves on pumps and an automatic throttling valve that maintains the pre-set rate.

Montreal station, handling the input from the refineries, is the key station on the line and all others synchronize their pressure and rate of flow with it. Line pressure is to be kept within a narrow range either side of 1000 psi.

Communication between stations and terminals is provided by a teletype system set up by Bell Telephone Company of Canada, and each station also is connected by telephone to the nearest local telephone exchange. Automatic push-button control of input and take-off is provided at Montreal and two terminals, Prescott and Clarkson. ★ ★ ★

It takes MUSCLES in the mud

PIPE laying is rough even under favorable conditions. But when you have to handle extra-heavy pipe through mud and muck, as in the above picture, the extra staying power of the Caterpillar D7 Tractor with MD7 Pipe Layer really pays off. The Cat outfits on this pipeline construction job in Texas are owned by the Oklahoma Contracting Corp. of Dallas.

Built to take the extreme strains of pipe laying and stand the grind of working days on end with little rest, these Caterpillar D7 Diesel Tractors with MD7 Pipe Layers are the units preferred by experienced operators, like A. B. Knipe, welding foreman on this job. He says, "We can always depend on Caterpillar-built machines to pull us through."

Balanced Caterpillar engineering matches power output to the job. Conveniently placed operating controls, separate load and boom line drums and clutches, and a special, long-lived Caterpillar transmission, mean accurate control—and "built-in" safety for the men on the job.

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THE PIPE LINE OUTLOOK

Industry's leaders express optimism for the coming year—See continued growth

THE pipe line industry has a healthy outlook for the coming year in the opinion of its leaders. This applies to crude oil, products, and gas pipe lines. Although there was active construction of crude oil and products lines in 1952, as one individual summarizes the situation, there is a definite need for all pipe line facilities now available, and with consumption steadily on the increase there will be a continuing demand for new pipe line facilities. Many see a particularly active expansion in the nation's products pipe line facilities. There will also be an expansion in gathering systems to fill the added trunk line capacity.

It is estimated that during 1953, $1,570,000,000 will be spent for production, underground storage, and transmission of natural gas. In 1952, $1,000,000,000 went into construction and expansion programs of natural gas pipe line systems. As a further indication of growth, 13,500 miles of gas pipe lines were approved or pending before the Federal Power Commission at the beginning of this year.

The following comments have been received by *The Petroleum Engineer* from a cross-section of the industry's spokesmen.

Frank C. Smith

President, American Gas Association, President, Houston Natural Gas

"The gas industry made many significant advances during 1952. Gas transmission and distribution companies overcame serious obstacles to achieve new records in the number of customers served, in volume of sales of utility gas, and in total revenues from sales of gas during the year.

"In spite of keen competition for steel, for manpower and for investment dollars, the nation's vast system of natural gas transmission lines extended into new territories adding nearly one million new customers to the gas utility mains. The industry spent approximately $1.2 billion dollars last year in expanding present facilities and on new construction. About $1 billion of this total was devoted to the construction and expansion program of the natural gas pipe line systems.

"A tremendous demand for gas services still exists. The American Gas Association estimates that nearly $1.7 billion dollars, an all-time high, will be spent on increasing the gas industry's underground storage capacity. More than 500 billion cubic feet of natural gas will be stored underground next year to help meet the demand expected from the 1,050,000 gas househeating customers who will be added to gas utility lines in the 1953-1954 heating season.

"Construction of more than 5800 miles of natural gas pipe line was authorized by the Federal Power Commission in 1951 and approximately 5000 additional miles were authorized for construction in 1952. Applications for nearly 13,500 miles of additional pipe line were approved or pending before the commission at the end of the year. These additions already completed bring the nation's natural gas pipe line system of gathering, transmission, and distribution lines to a total of about 342,500 miles today.

"The American Gas Association's Statistical Bureau has estimated that more than $5.6 billion would be spent by the gas industry in the five-year period 1952 through 1956 for new construction and expansion of its present plant. Some shortages of steel and delays in obtaining necessary certificates from the FPC acted as a brake on construction expenditures, which totaled about $1,170,000,000 in 1952, compared with a record peak of $1,461,500,000 spent in 1951; however, it is believed that construction expenditures in 1953 will climb to an all-time high level of $1,680,000,000 unless some drastic change occurs in the national economy.

"The bulk of construction expenditures next year will be devoted to the natural gas branch of the industry, following the pattern of the past few years. An estimated $1.57 billion will be devoted in 1953 to expansion of production, transmission, and underground storage facilities for natural gas.

"While several large transmission lines are planned, surveys made by AGA indicate that an important segment of the industry's expanded capacity will be achieved through increasing the horsepower capacity of compressor stations, by looping present transmission lines, and other measures utilized to conserve materials and to reduce expansion costs.

"Although the gas industry faces many challenges, its prospects for establishing new records in 1953 are most favorable. Natural gas lines will extend into new territories and new customers will be added to gas utility lines. New reserves of natural gas are being discovered. With some of the threat of further federal encroachment eliminated with the change in administration, exploration and wildcatting should accelerate. Economists believe the nation has reached the peak of its war production, so more materials should be available for the gas industry's aggressive construction program next year."

Millard K. Neptune

President, Platte Pipe Line Company

"The outlook for the pipe line industry in 1953 is good—rosy. Business is entering the new year with an outlook of economic prosperity and political understanding. There will be no great decrease in the influence of government on business; however, the profit motive will be recognized, not as a sinister device, but as an implement to build an even higher standard of living. Pipe lines will contribute further toward reducing end use costs and, hence, toward this higher standard of living.

"The year 1953 should be particularly good for the Rocky Mountain region. It will be the first full year of operation of the Platte Pipe Line, and the year should see the installation of a number of small pipe line projects for the purpose of connecting new areas to the Platte line. The high rate of exploration and development which has already resulted from the simple assurance that a pipe line would be built will be further augmented now that revenues are coming in from oil sales."

Harold Decker

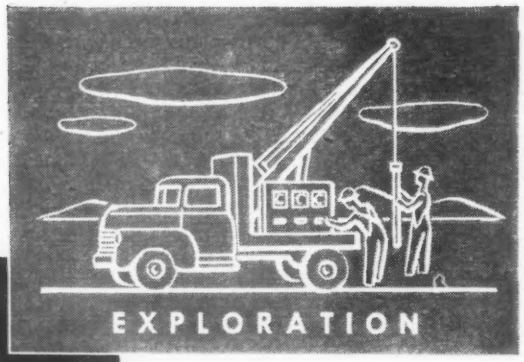
President, Houston Pipe Line Company

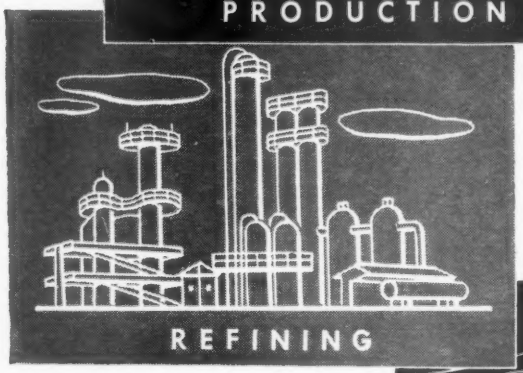
"In the Texas Gulf Coast where all of the operations of Houston Pipe Line Company are situated, we are looking forward to a continued growth in natural gas demand. New industries are coming into the area and already established plants are being expanded thus causing a constant increase in industrial natural gas needs both for fuel and a raw material. As the population of the area grows, home consumption of natural gas is correspondingly on the rise. We expect the rate of growth which has been established in the past few years to continue without let-up through 1953."

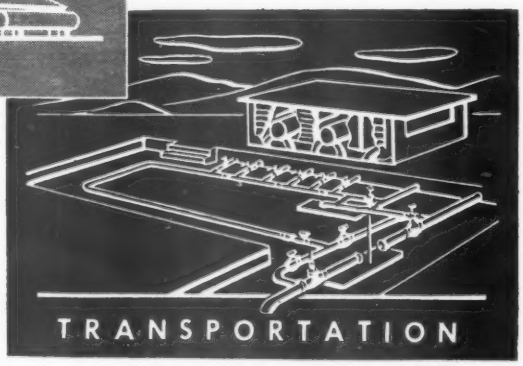
T. S. Johnston

President, Interprovincial Pipe Line Company

"1952 has been a very successful year for us in Interprovincial. We were able to put our 5 new stations in the line and complete a 100-mile loop as well as construction of additional tankage at Superior. Our annual throughputs increased by over 11,000,000 bbl during







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the year and movement from Superior to eastern Canadian refineries increased from slightly over 13,000,000 bbl in 1951 to something above 19,000,000 bbl this year.

"1953 we feel will show an increase in our throughput generally but for the most part we will be occupied with the construction of our announced extension of the system from Superior, Wisconsin, to Sarnia, Ontario. This will be a 30-in. line approximately 625 miles long starting initially with one station. The initial throughput through that portion of the system will be about 100,000 bbl a day with an ultimate throughput of something over 300,000 bbl per day.

"As the market demand and refining capacity increase in Ontario, further expansion will, of course, be made in the existing Interprovincial and Lakehead system to achieve the ultimate throughput in the Superior-Sarnia section.

"In 1953 we plan on looping about 135 miles of line in Canada with 24-in. pipe and, of course, there will be additional horsepower added to the stations.

"Generally we are most optimistic on Canadian production and the ability of the refineries to keep abreast of market demand."

L. R. Dickinson

Manager, Eastern Pipe Line Division, Socony-Vacuum Oil Company, Inc.

"The demand for added pipe line capacity throughout the United States was not satisfied by construction during 1952. Many projects that were begun during this year must depend for completion on pipe and equipment produced in 1953. Even though there are indications that the industry will encounter more stringent requirements in connection with financing new pipe line projects, apparently all of the line pipe produced in 1953 will be utilized and expenditures during the year for pipe lines and related facilities will at least parallel those made in 1952.

"There is an increasing interest in pipe line transportation in countries outside of the United States, although not on the same scale as in this country. Except for an upset in world-wide conditions, 1953 activities throughout the pipe line industry should at least equal those of 1952."

James B. Black

President, Pacific Gas and Electric

"California's tremendous rate of population and economic growth shows no indication of abating. In 1952 Pacific Gas and Electric Company continued its large postwar program of capital investment. Expenditures for the year on additional gas department facilities amounted to more than $17,000,000, bringing total postwar gas system expenditures to more than $187,000,000. It is estimated that further expansion in this department in 1953 will exceed $32,000,000.

"Translating such figures into terms of new customers connected and total gas sendout expresses the significance of this expansion. Since 1945 this company has added 363,000 gas customers to its lines. This is an average rate of growth of 52,000 new customers per year. The year 1952 was slightly below the average, with 50,000 new customers connected. It is expected that additions in 1953 will be somewhat in excess of this figure.

"Gas sales have grown with corresponding rapidity. In 1945 sales of gas were over 135 billion cubic feet. By January 1, 1953, annual sales will have increased to more than 221 billion cubic feet.

"In order to continue to take care of present customers and provide service for the more than 50,000 new customers anticipated in 1953, the capacity of the company's gas system must be considerably increased. The Federal Power Commission has approved an increase in capacity of the Topock-Milpitas "Super Inch" transmission main from its present 400,000,000 cu ft per day to 550,000,000 cu ft. Another application for an increase to 700,000,000 cu ft has been submitted to the commission. We hope for early hearing and favorable decision.

"To accomplish this program a number of sections of parallel pipe line will be looped into the Topock-Milpitas 34-in. transmission main and compressor station capacity will be supplemented. This and other projected construction will require some 150,000 tons of steel.

"The fulfillment of this plan will depend primarily on the amount of steel available. The increased steel-making capacity in this country will, we believe, permit the delivery of steel in adequate amounts to meet our construction requirements."

G. S. Patterson

President, The Buckeye Pipe Line

"There undoubtedly is a definite need for all of the now available pipe line facilities for the transportation of crude oil and oil products, especially the latter, with a growing demand for more. With consumption of petroleum products steadily on the increase, and since pipe lines have proved to be generally the most economical method of transportation, particularly to inland areas, it is the opinion of the writer that there will be a continuing demand for new pipe line facilities.

"This company had added substantially to its crude and refined products pipe line capacity during 1952. For example, we have recently completed construction of an extension to our Midwest products division line to Toledo, Ohio. We have also completed construction of a 16-in. refined products pipe line from Linden, New Jersey, to Allentown, Pennsylvania, where a connection will be made with the lines of the Tuscarora Oil Company for delivery of products to terminals west of Allentown as far as Pittsburgh, Pennsylvania. In 1953, we have scheduled for construction a 14-in. line from Allentown through the Scranton-Wilkes-Barre area to Binghamton and Auburn, New York, and a 10-in. line east from Auburn to Syracuse, New York, and west from Auburn to Caledonia, New York, where a connection will be made with The Buffalo Pipe Line Corporation, permitting transportation to terminals at Rochester and Buffalo, New York areas. This entire eastern system will comprise some 330 miles of new products lines."

Joseph L. Seger

President, Interstate Oil Pipe Line

"As was the case a year ago, our company is moving crude oil in record volumes. In view of the proposed enlargement in our shippers' refining capacities, we anticipate that our deliveries in 1953 will exceed those for 1952. However, we do not think the increase will be as large as was the 1952 increase over 1951, which was about 5 per cent.

"Due to some delays in pipe deliveries, our 1952 construction program will not be finished until well into 1953. This, together with our program to modernize and enlarge our Shreveport to Baton Rouge trunk line and to relocate certain other trunk lines to remove them from the Shreveport metropolitan area, will result in construction projects totaling 260 miles of 8, 12, 16, 18, and 22-in. pipe. The program on our Shreveport-Baton Rouge line will also involve the construction of one new station and the abandonment of four old stations.

"We believe that Interstate's outlook is about the same as the outlook for the industry as a whole; 1953 should see a continuance of the high volume movements of the past several years. Doubtless the industry will continue to expend substantial sums to expand its total throughput and to replace obsolete facilities with efficient modern ones."

G. H. Supple

Director, Pipe Line Department, General Petroleum Corporation

"I feel that the following comments could be made with respect to the outlook for the pipe line industry in California for 1953:

"1. There will probably be an expansion in the handling of refined products by pipe line.

"2. The higher average gravity of recent discoveries in California fields is making it possible for pipeliners to modernize their old lines and stations with more efficient equipment at more economical costs.

"3. All of the larger projects, which have been in progress, seem to have been completed, and future construction apparently hinges on the contingency of new discoveries.

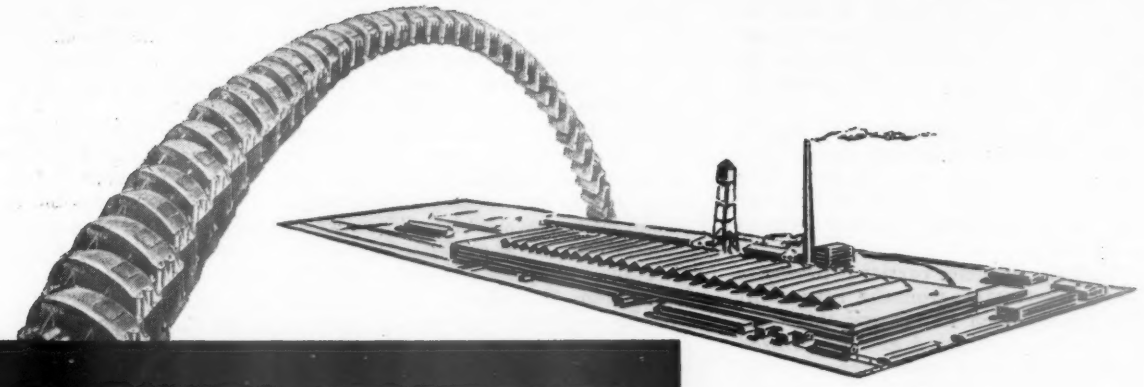
"4. Total volumes handled will continue to be governed by market demands."

Charles R. Younts

President, Plantation Pipe Line

"The year 1953 should see continued growth of the pipe line industry in the southeastern area of the United States. The rapid industrial and population growth in this area over the past decade points to increased throughput in both the gas and products pipe line industries.

"In our Plantation Pipe Line Com-



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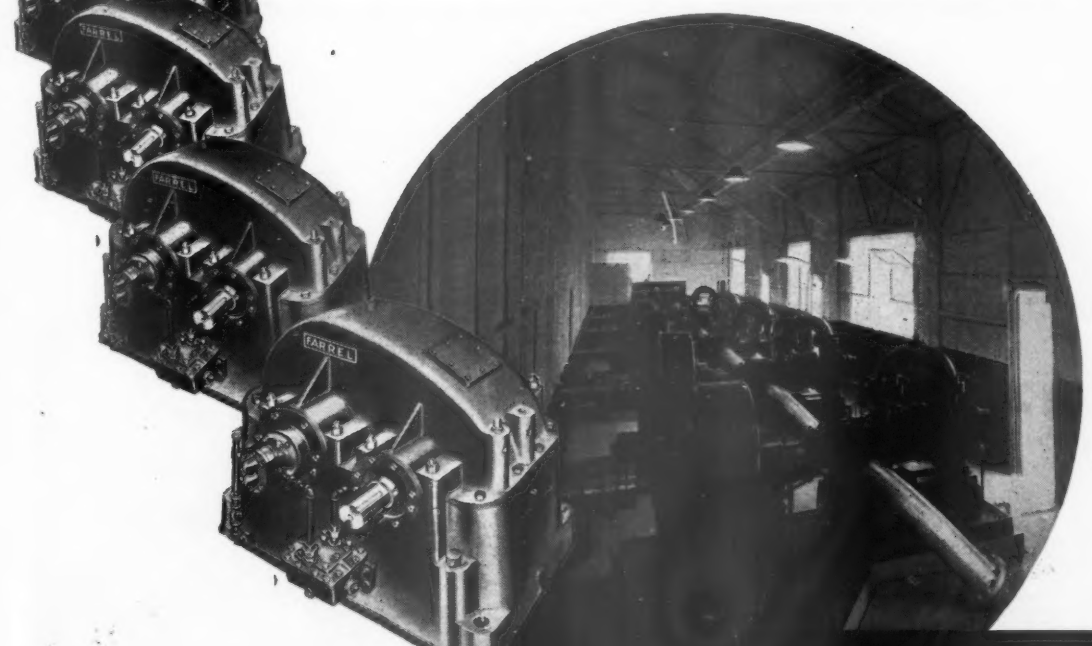

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pany we have undertaken to meet the increased demand and anticipate future demands for petroleum products by more than doubling our throughput capacity in 1951-52.

"Our shipper companies are rapidly expanding their facilities to handle their present and future requirements. New shippers have been able to tie-in to our system as additional capacity became available.

"A large diameter carrier is presently under construction from the Texas Gulf Coast into Baton Rouge and this, coupled with an enlarged and modernized dock for handling water shipments up the Mississippi into Baton Rouge, will facilitate receiving sufficient quantities to take care of anticipated demands.

"New techniques are being employed by the construction of remotely controlled stations on our lateral lines. Both microwave and leased-wire media are being utilized on these projects.

"In summary, we feel the Southeast is in a good position from the pipe line industry viewpoint to meet the growth and development in this area which is expected to follow the upward trend experienced over the past decade."

Grove Lawrence

Vice President, Southern California Gas

"We expect the growth of our system, and the demand for gas, to increase during the next few years at rates only slightly smaller than those we have experienced recently. We are expecting to add over 50,000 meters to the Southern California Gas Company system in 1953.

"In anticipation of continued growth, we applied for, and received from the Federal Power Commission, a certificate of convenience and necessity for an additional 150,000,000 cu ft per day from out-of-state sources. Construction on the necessary added facilities, which includes 20 miles of 30-in. loop pipe line, two additional 5000-hp gas-turbine-driven compressor stations, and 3500-hp additional compressor capacity at the existing station near the Colorado River started in December.

"By the middle of December, we completed the installation of approximately 10 miles of 22-in. at Ventura, which increases deliverability from underground storage by about 100,000,000 cu ft per day.

"We expect these projects will enable us to satisfy our firm requirements for the next four or five years, and to supply a larger volume to industrial users in 1953 than they received in 1951 or 1952."

R. K. Paine

Manager, Pipe Line Department, Standard Oil Company of California

"The outlook for major crude oil pipe lines in California does not indicate any need for major expansion at this time. Sufficient pipe lines are available to handle the present production and no large increase in production is expected unless the present price ceiling on oil prices in California is raised to encourage a more extensive drilling operation.

"The study of products pipe line needs on the West Coast is continually under inspection, and as the consumption of products increases with expanding population and industry, more products pipe lines can be expected to justify themselves."

W. C. Kinsolving

President, Sun Pipe Line Company

"The year 1952 has seen the culmination of quite a few major crude oil and product pipe line systems.

"The completion of these new lines and the expansion of existing facilities in 1952 represents an overall increase in our crude oil and refined product pipe line capacity, and it is doubtful if such a comprehensive construction program will continue through 1953. Several major programs are contemplated, however, and others may be announced if there is a relaxation of controls on line pipe.

"Among the crude oil pipe line projects announced for 1953 are Lakehead's line from Superior to Sarnia, Ontario, extending the Interprovincial system all the way from the Alberta oil fields to Sarnia, and the West Coast Pipe Line, which is projected from West Texas to California. Among the product lines proposed are: The further expansion of

"Welding 8" line preparatory to shoving across a South Louisiana marsh"

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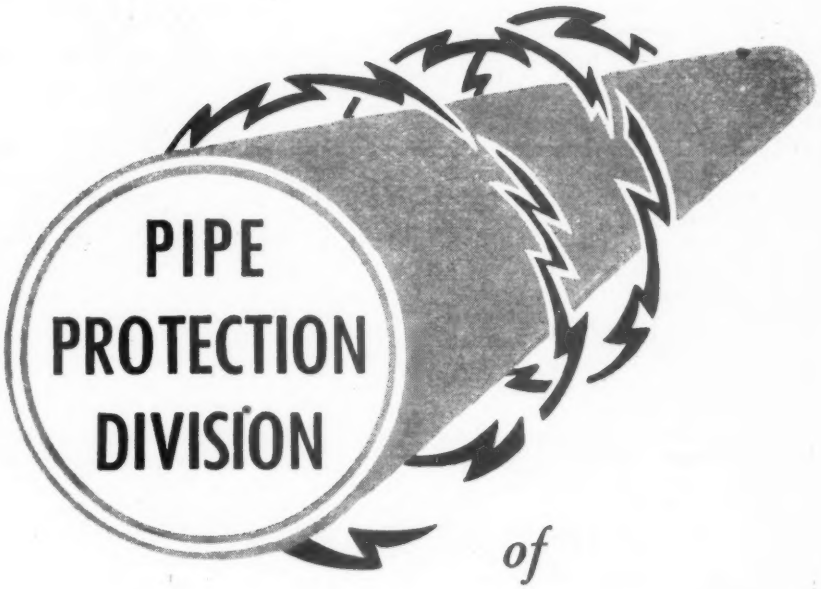

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the Plantation system; the construction of the Buckeye system from Linden, New Jersey, to points in Pennsylvania and New York state; the Evangeline system from Port Arthur to Baton Rouge; the Wolverine line from Chicago to the Detroit area; Sun Oil Company's line from Sarnia to Toronto; the United States Pipe Line Company's large project from the Beaumont-Houston area to New York harbor; the Gulf system to Memphis and Nashville; the Harbor Products System from the Philadelphia refinery area to New York harbor, and numerous smaller extensions.

"A decided decrease in the number of major crude pipe line projects for 1953 is apparent, only two having been announced to date. One of these, the West Coast Pipe Line, is of a controversial nature and some question exists as to whether sufficient commitments can be obtained from shippers and West Coast refiners to assure its financing. Also, completion of financial arrangements has not been announced for the largest product system projected for 1953, namely, the United States Pipe Line Company, although this project has the approval of the PAD and has received firm pipe allotments.

"The inference to be drawn, as far as crude lines are concerned, is that pipe line capacity has caught up with available supplies, and it appears that this condition will prevail until new oil producing areas, such as the Williston Basin, are developed. This does not appear to be true of the product pipe line picture, however, since many marketing areas are still without pipe line connections and the extension of systems into these areas would seem to be economically sound. Many such projects, however, will have to await the relaxation of controls on line pipe. The expansion of product systems has been affected to a greater extent by government controls than has that of crude systems, since defense essentiality was the PAD's primary consideration in granting pipe allotments, and because of this factor the bulk of available pipe was allotted to crude lines. The same restriction applies to the construction of lines for the transportation of LPG. At the present time, lines in this category represent a very small fraction of the total pipe line mileage, but the next few years may see a very appreciable growth in LPG pipe line transportation systems."

C. S. Mitchell

President, Cities Service Pipe Line

"In our opinion, crude oil demand should increase in 1953.

"With Platte Pipe Line completed and two other large diameter crude lines from West Texas to the Gulf Coast expected to be completed early in 1953, crude carrying capacity from West Texas should be much more nearly adequate than in the past. Completion of Trans Mountain should provide the necessary outlet for Canadian crude for the immediate future.

"It is our opinion that these new lines should satisfy the most pressing need for crude pipe line outlets except in the Williston Basin; and it does not seem likely that any appreciable amount of steel will be required in the Williston during 1953.

"It can be expected that a concerted effort will be made to construct and extend gathering systems in an effort to fill the added trunk line capacity soon to be available, and to serve new fields.

"Since most of the major crude oil lines are complete or nearing completion, more steel should be available for gathering systems and products lines.

"A number of products pipe line projects are now underway or contemplated for the immediate future. With increased availability of steel, other similar ventures should be announced during 1953."

J. L. Burke

President, Service Pipe Line Company

"Indications are that competition will be more vigorous in the pipe line industry than ever before. In the past year, several new large-diameter lines have been completed and others are nearing completion. Capacity of a number of other pipe systems has been increased by addition of stations or laying large-diameter loops. These large-capacity lines require continuous sources of crude oil to provide the volume needed for profitable operation, and because of this need to fill the lines competition will be strong, especially in making gathering connections.

"In trunk operations, competition by the low-cost large-capacity lines will redouble efforts of all in the industry to seek more efficient operating methods."

Loren H. Kahle

Deputy Coordinator of Transportation, Standard Oil Company (N. J.)

"With an ever-increasing demand for petroleum and its products, additional wells will be drilled and produced and additional transportation will be required to move the crude to refineries and to distribute the products to the ultimate consumer. On the basis of current estimates it appears that the worldwide demand for petroleum products will be in the neighborhood of 700,000 bbl per day more in 1953 than in 1952 and transportation facilities will have to be provided to meet this requirement. This continual increase in demand presents a challenge to the industry to provide for economical transportation obtained by enlarging existing facilities and building new ones.

"The Jersey company's affiliates will continue to do their part in providing petroleum products to consumers at reasonable prices throughout the world and pipe lines will provide efficient transportation where needed. Our affiliates in the U. S., Canada and Venezuela are interested in various projects for increasing pipe line throughputs, and in other parts of the world are continually studying the feasibility of new and more efficient means of transportation."

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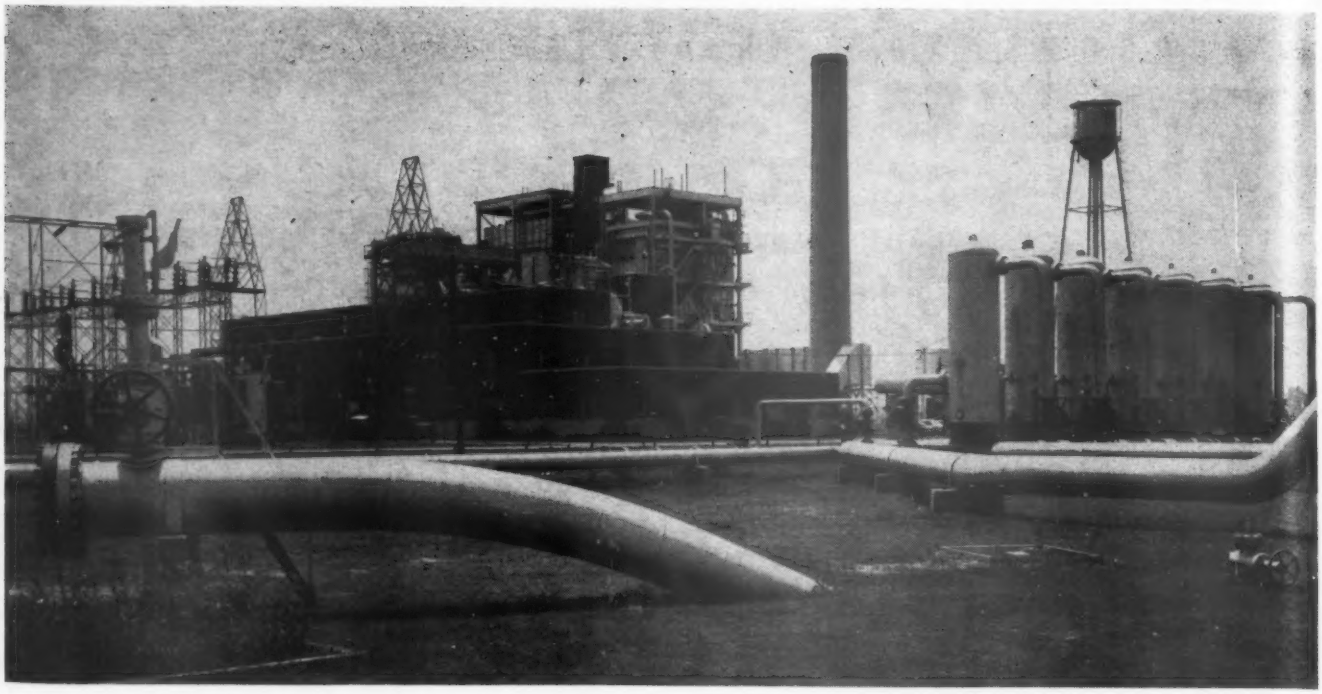

The Cecil S. Lynch generating plant of the Arkansas Power and Light Company, background, and Texas Eastern's Station 5, North Little Rock, Arkansas, are next door neighbors. Station piping and scrubbers, foreground, and the generating plant blend to portray the close relationship between kilowatts and cubic feet.

Electric Power for Gas System Operation

Texas Eastern Transmission Corporation is supplied electricity by 120 power companies — The annual bill is $8,000,000

Electrical control panels like the one below at Texas Eastern's Kosciusko, Mississippi, station contain all necessary metering, switching, and regulating devices to supply power to the station's compressor motors and other electrical equipment.

KILOWATTS and cubic feet have close relationship in Texas Eastern Transmission Corporation's system. Kilowatts of electric power consumed in transmitting millions of cubic feet of natural gas reach tremendous proportions during each day's operation.

The amount of electricity purchased annually makes the company one of the nation's major consumers of electrical energy. Texas Eastern's annual electric power bill amounts to approximately $8,000,000. Along the pipe line system from Texas to New York more than 120 power companies supply the electricity used by the company, the major requirements being served by 16 different utilities. Monthly payments for service are made to the local offices where Texas Eastern stations and offices are situated. These payments, amounting to thousands of dollars in most cases, are made through local banks, thereby boosting community financial standings.

Texas Eastern used approximately 1,009,574,000 kw-hr of electricity during the year ending September 30, 1952. In the year ending July 31, 1952, the elec-

"The enthusiastic response of our employees . . ."

ALDEN G. ROACH
President, Columbia-Geneva Steel Division and Consolidated Western Steel Division, United States Steel Corporation

"It is most gratifying to me that the employees of the Columbia-Geneva Steel Division and the Consolidated Western Steel Division of United States Steel Corporation have accorded meaning to their belief that the security of our nation rests upon our cooperative effort. The enthusiastic response of our employees made me doubly glad we conducted a person-to-person canvass for the Payroll Savings Plan for U. S. Defense Bonds."

The experience of Columbia-Geneva and Consolidated Western Divisions of United States Steel Corporation is not an isolated one.

Since January 1, 1951, hundreds and hundreds of companies have conducted person-to-person canvasses of their plants and offices. In every instance, employee participation in the Payroll Savings Plan has increased —sometimes from a low figure—to 60, 70, 80%. In a number of plants, participation passed the 90% mark.

The explanation is simple.

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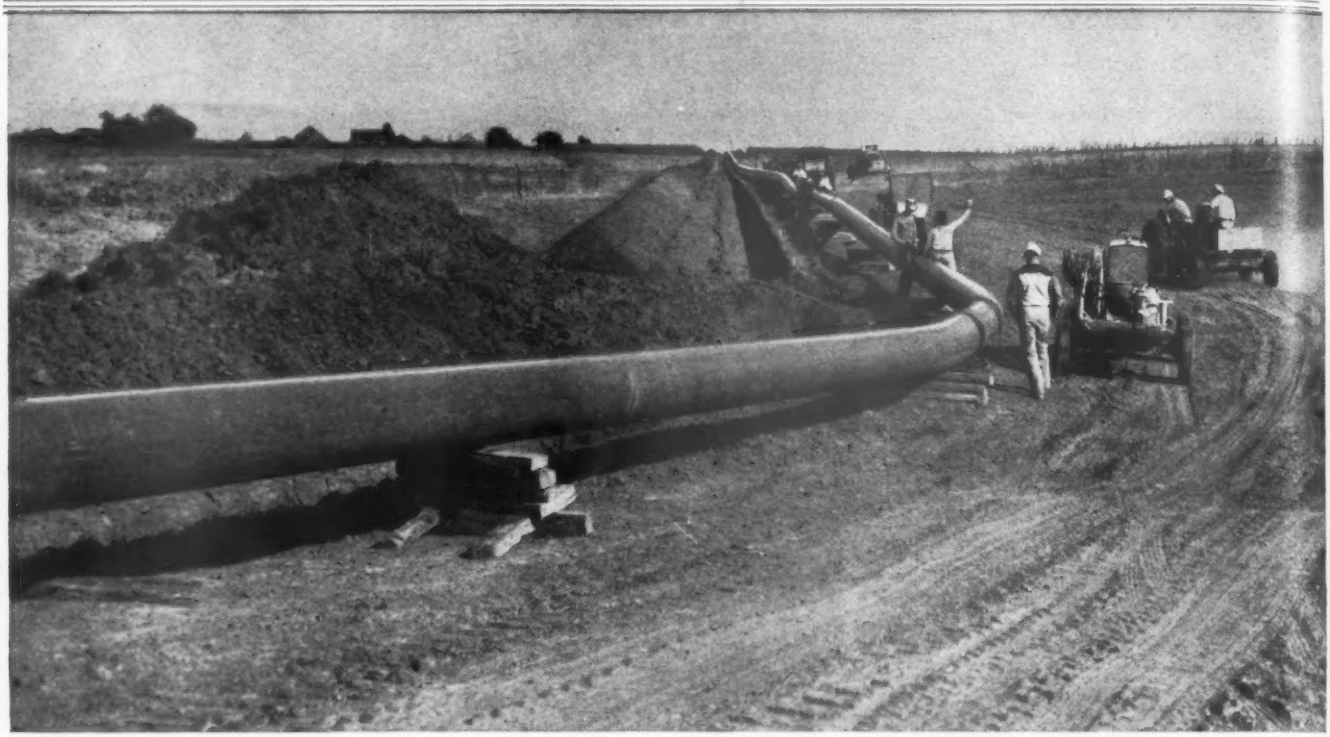
The Petroleum Engineer

PIPE LINE PROGRESS



20-inch A. O. Smith line pipe being welded on the Rumsey Brothers, contractors, Nebraska spread of the Platte Pipe Line Company's 1,056-mile crude transmission line

Platte Pipe Line . . . New Outlet for Rocky Mountain Crude

A new 20-inch crude transmission main now delivers Rocky Mountain production to refineries at Wood River and Chicago, Ill., Bayshore (Toledo), Earhart (Detroit), Olean, N.Y., and Falling Rock, W. Va.

It is the 1,056-mile line of Platte Pipe Line Company, a Delaware corporation with stock owned by Sinclair Pipe Line Company, The Ohio Oil Company, Continental Oil Company, The Pure Oil Company and Toronto Pipe Line Company.

Big Horn, Wind River, Great Divide and Powder River basins of Wyoming and the Denver-Julesburg basin of Colorado and Nebraska supply the crude from existing producing wells, previously shut-in wells and recently drilled wells. By opening this Rocky Mountain area, new reserves and production from new drilling are now made available.

The pipe line begins in the Big Horn basin near Worland, Wyoming, and stretches in a southeastern direction across Nebraska, northeast Kansas and Missouri. Eastern terminal is Wood River, Illinois, from where other pipelines distribute the crude to refineries to the north and east.

A. O. Smith welded steel line pipe comprises more than half of this 20-inch main, a dominant factor in the completion of another great petroleum pipe line.

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DEPENDABILITY THROUGH RESEARCH AND ENGINEERING

One of the standby electrical generator units in Texas Eastern's system. Operated by gas-fueled engines, units start automatically should normal power supply fail. They produce sufficient power to operate valves and other electrically-operated control units.

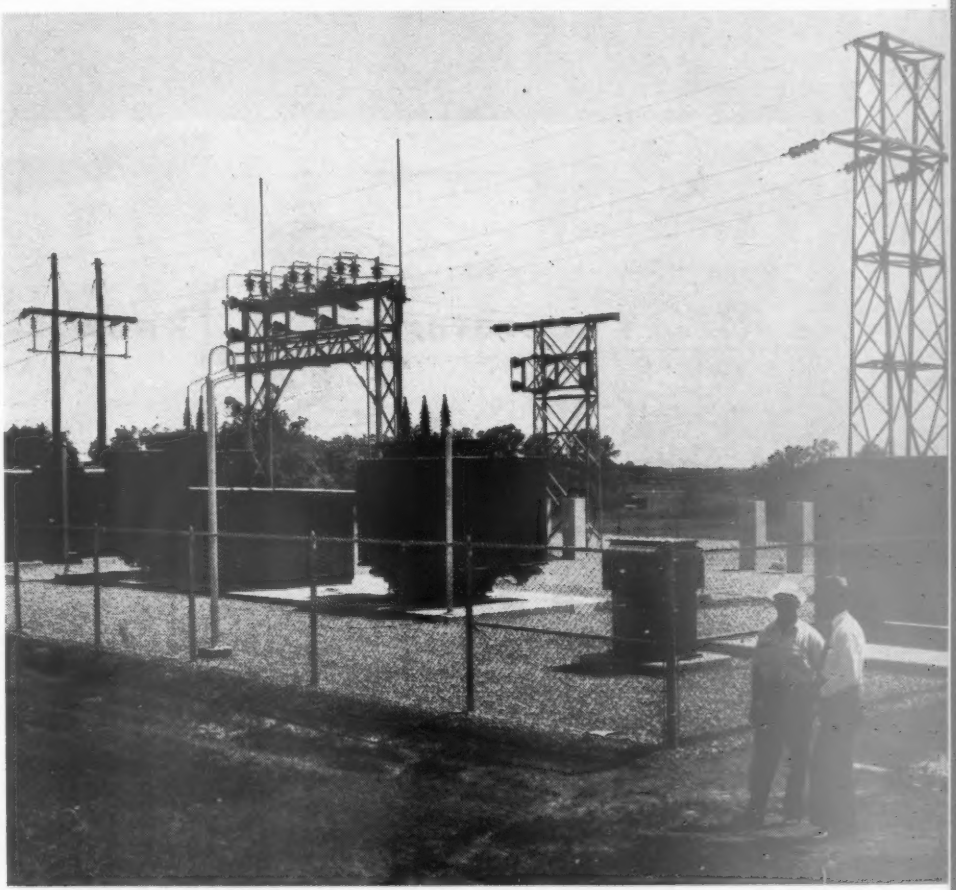
tric utilities of the United States produced some 386,534,118,000 kw-hr. From these figures it can be seen that Texas Eastern's annual electric power requirements equal about one full day's production of the entire electric utility output of the nation.

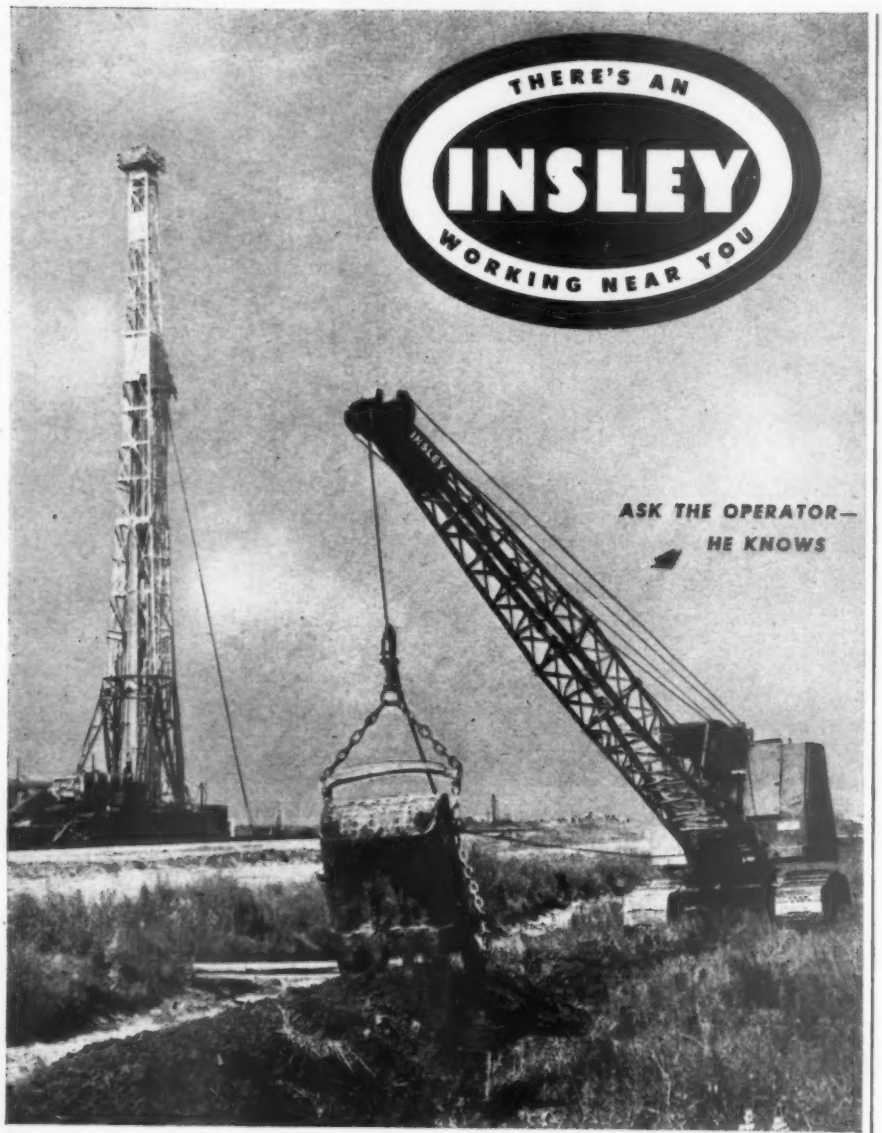
The largest portion of this tremendous amount of power is used by the company's centrifugal compressor stations, where gas compressors are driven by electric motors. Today there are 129 of these powerful motors ranging in size from 1250 to 2500 hp in Texas Eastern's 20 centrifugal stations. One of the most prominent identifying marks of this type station is the group of huge outdoor transformers at each station site. Throughout the system there are 48 huge power transformers in use. These range in size from 3750 kva to 6000 kva. Comparison indicates the high capacity of such equipment: A 3750 transformer could serve from 800 to 1000 residences.

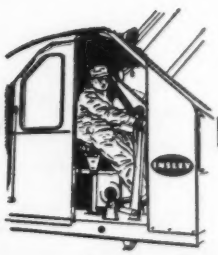
In addition to powering electrically operated compressors, large volumes of electricity are used by Texas Eastern to power other equipment. Included are fin-fan cooling units, automatic shutdown systems, elaborate and specialized lighting systems, radio communications equipment, and various small electrically powered units. Station residential areas and the company's several office centers also account for large amounts of power consumed.

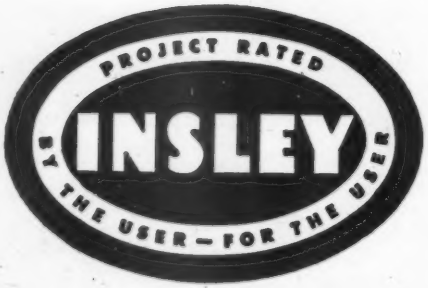
One of the more spectacular uses of electricity along the pipe lines is in corrosion control. Although consumption of electricity for this particular work is relatively small, the role it plays is very

Electrical sub-stations such as this one on the grounds at Texas Eastern's Gladeville, Tennessee, station contain the large heavy-duty transformers required to supply power of proper voltage and volume to centrifugal stations.





The INSLEY operator  knows..



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important. Corrosion of underground pipe lines takes place when conditions are such that an electrical action causes a current to flow away from the pipe and through the ground. This stray current carries with it minute particles of metal from the pipe, and if the process were permitted to continue long enough the pipe wall could become damaged. To counteract this corrosion action, an electrical charge is put into the ground at points along the pipe line. Electricity flowing into the ground from the external source acts as a barrier and causes current flow from the pipe to be reversed, thereby controlling corrosive action.

The most recent addition to the list of electrical installations along Texas Eastern's pipe lines is the company's microwave communication system, the third-longest microwave system in the nation. Electricity powers electronic units used in operating this modern method of communication between various points on the system.

The amount of electric wiring required in Texas Eastern compressor stations alone amounts to some 400 miles, and stations are equipped with control panels and associated apparatus of the type required for heavy-duty use of electricity. Such installations include equipment other than that used in normal operations. There are 75 standby power units in the Texas Eastern system. These units are all of the automatic starting type. Should the regular power supply fail the standby generators start operation automatically and provide power for lighting, motorized valves, and, in some cases, the entire operational needs.

It takes men with specialized training to supervise electrical installations on Texas Eastern properties and to maintain equipment. Company engineers engaged solely in electrical engineering and station electricians are kept busy in this important phase of Texas Eastern's operations.

As the natural gas transmission industry is one of the largest consumers of electric power in the United States, so is the electrical industry a major consumer of gas. Many power and light companies use gas to power electric generators where a sufficient supply of gas is available. Although the number and size of hydro-electric plants continues to increase as demand for more power soars, thermal energy is used to produce about 70 per cent of electric energy generated in the nation. Gas, coal, and oil are the fuels used in this method of driving the generators that produce electricity.

Because each industry utilizes the product of the other in perpetuating service, the ties between gas and electric power are secure. This reciprocal use of two forms of energy in making each available in greater abundance contributes much to America's high standard of living. Were it not for ample supplies of gas and electricity throughout the nation, many would be denied the "better things in life." Along Texas Eastern's natural gas pipe line kilowatts and cubic feet make a working team that plays a big part in producing widespread advantages. * * *

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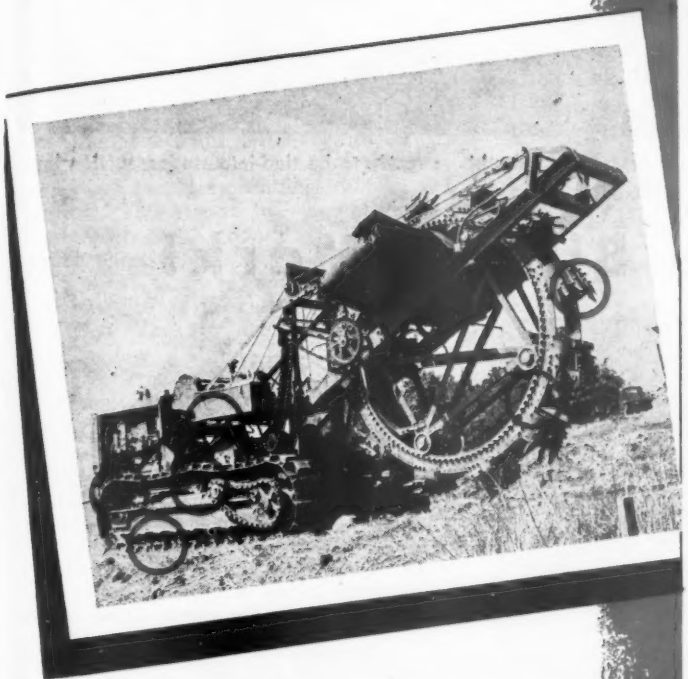
Keeps parts in service... in better operating condition!



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Applied by automatic or manual welding methods, Stoody Alloys usually double part life—or more. Ask your Stoody Dealer for details. He's listed in the Yellow Classified Telephone Directory under "Welding Equipment and Supplies."

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All types of ditcher teeth last longer with Stoody Hard-Facing. Normal life of teeth illustrated was 2800 feet of ditch. Protected with Tube Borium, 17,200 feet had been dug when photo was taken. Estimated total: 40,000 ft.

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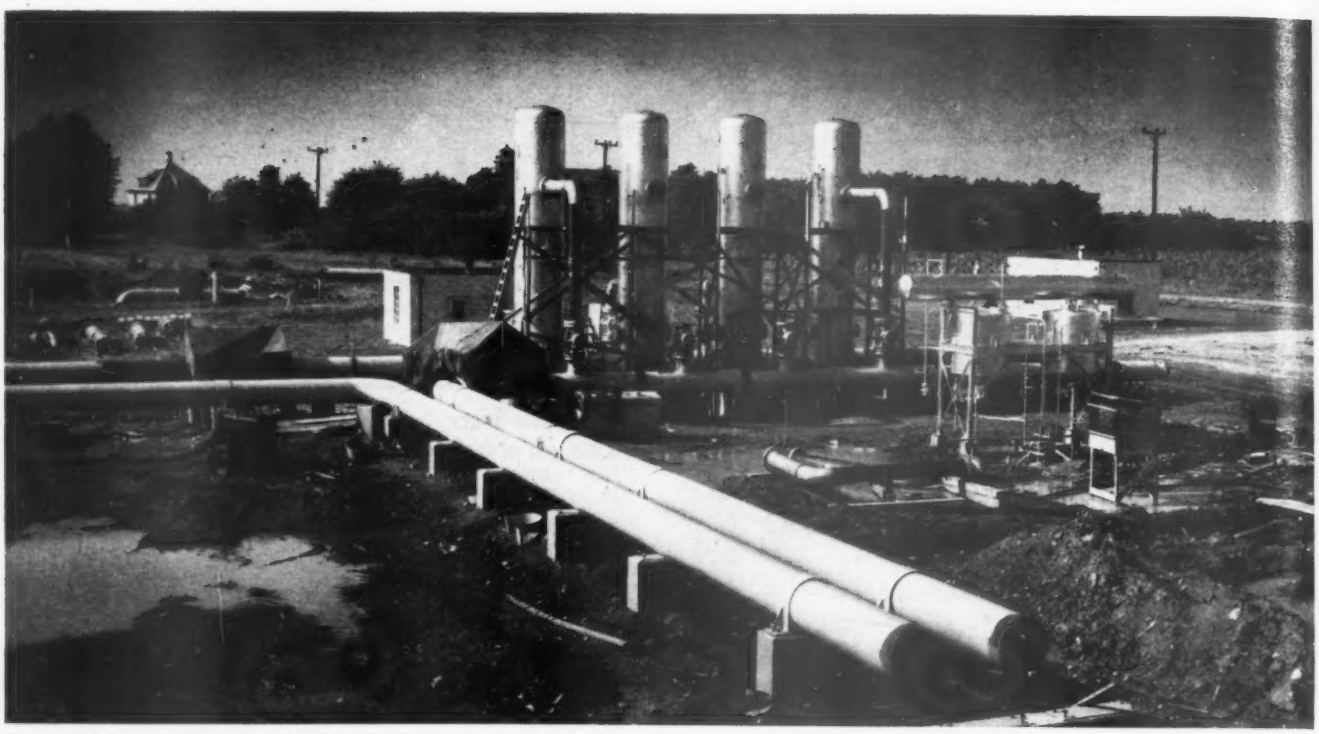


Scrubbers ready to be tied-into station suction lines.

Well Over the Billion Mark!

Latest construction in Tennessee Gas' never-ending program of growth adds 528 miles of pipe line, 93,900 horsepower, and places the daily capacity at 1,310,000,000 cubic feet

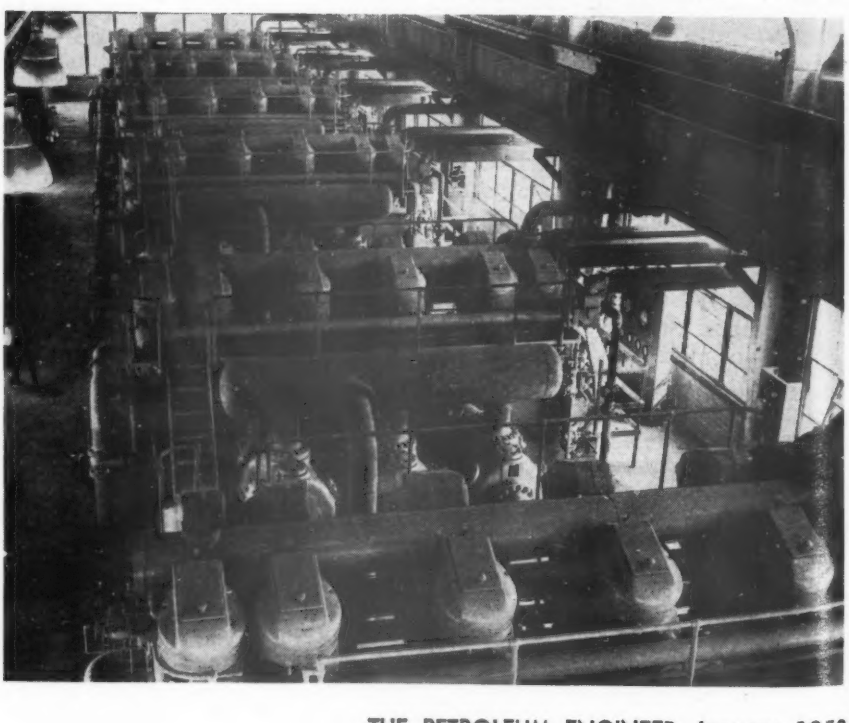
FRANK H. LOVE*

CONSTRUCTION recently completed by Tennessee Gas Transmission Company brings the capacity of that system to 1,310,000,000 cu ft a day. Included in the program was the erection of four new compressor stations in New York, Pennsylvania, and Ohio, additions to 16 existing stations, and the laying of 528 miles of main pipe line parallel to the existing system. At the new stations a total of 25,520 compressor horsepower has been installed, and at existing stations 68,380 hp added, making a total for the entire system of approximately 459,000 hp.

Since its original completion in 1944, Tennessee's policy has been one of continued growth and expansion. Today, it has three parallel lines throughout more than half its system, and in some places four lines.

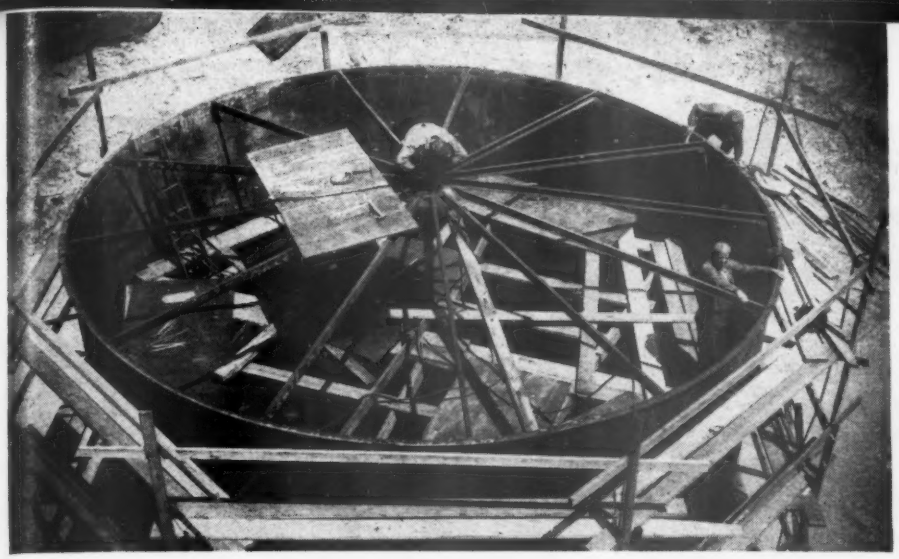
The system is a single line from its origin near the Texas-Mexico border for about 70 miles. It is a double line north to about Refugio, triple to about Edna, double again to Station 2, East Ber-.

Compressor engines at the Carrollton, Ohio, station.



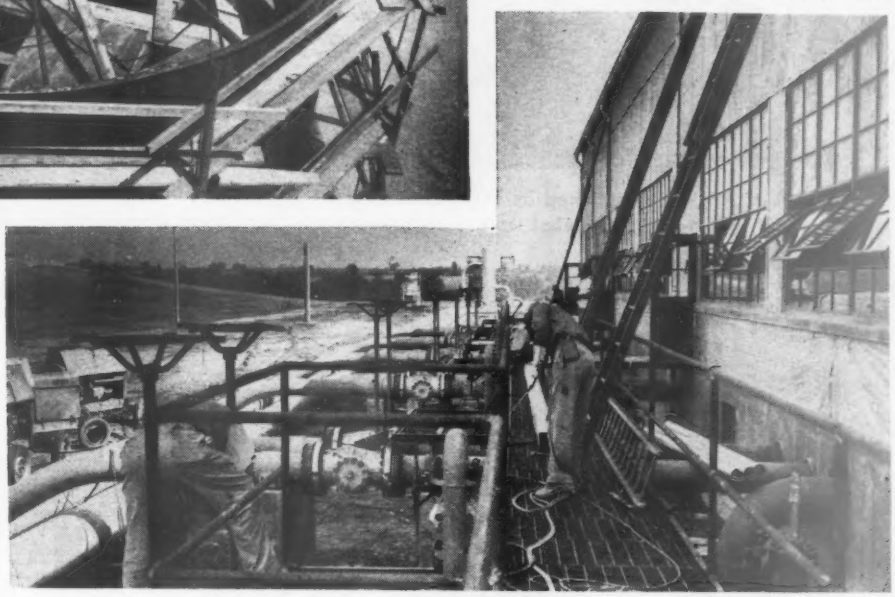
**Oil and Gas Pipelining* editor.

EXCLUSIVE



Water storage tank under construction at Nassau, New York. Welders are working on steel supports for tank roof.

Workmen coat and paint steel catwalk over suction and discharge lines at Carrollton, Ohio.



nard. From there to Station 5, Natchitoches, Louisiana, it has three lines; from the latter point to the northeastern part of Kentucky four lines practically solid, with two lines running into West Virginia. The system stretches onward from northeast Kentucky as a single line through Ohio, except for 82 miles along which there are two lines, and is a single line on through Pennsylvania and New York to the Massachusetts state border.

These developments have resulted in three complete compressor engine buildings at many locations and two at many others, with manifolds tied together. Thus there are three complete installations at stations numbers 6, 7, 8, 9, 10, 11, and 12; two at numbers 1, 2, 3, 4, 5, 13, and 14, and one at all other sites. Normally, where there are three buildings at one site, one set of auxiliary equipment is tied into two compressor buildings, the third compressor building requiring a second auxiliary installation. This arrangement serves to scatter the equipment in the interest of safety and also eliminates the possibility of a complete plant shutdown.

As a further means of safety, the design of all stations includes remote control points for emergency shutdown. Such shutdown devices are placed at each auxiliary building and at the office. Installations are on the opposite side of the building from high-pressure gas lines, which provides safety for anyone operating the shutdown equipment.

All compressors installed in the four new stations are single-stage units. The number installed at each and the horsepower are shown in Table 1. No gas cooling is done at these stations because of

Gas-engine-driven generator units for supplying electric power.

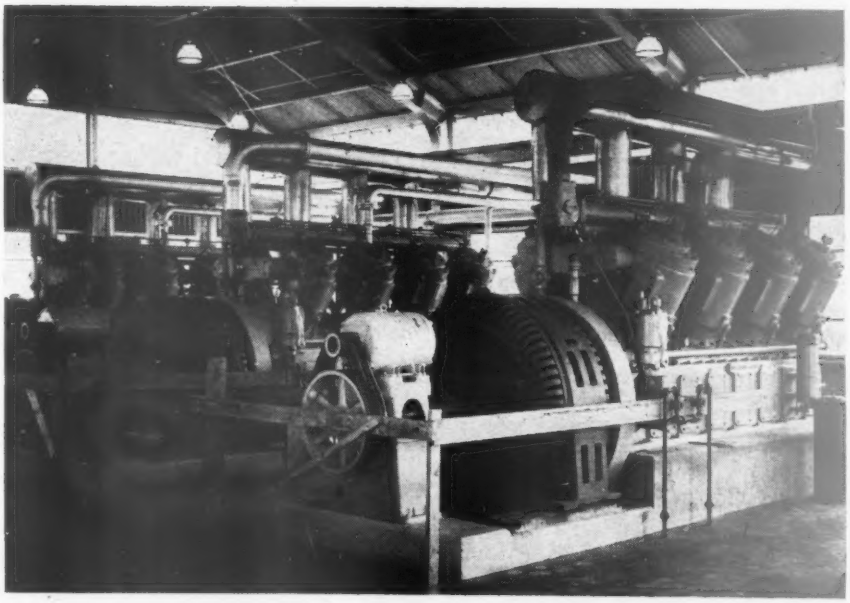
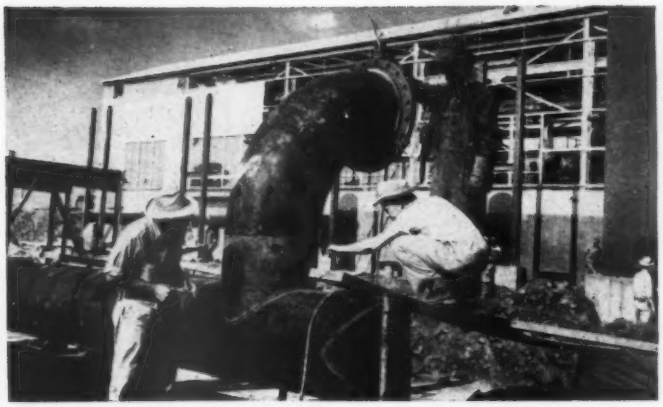


TABLE 1. New stations on Tennessee Gas Transmission Company system.

Station number	Location	Type of units	Number of units	Horsepower per unit
254	Nassau, New York	Worthington UTC-165	6	1000
245	West Winfield, New York	Worthington UTC-165	5	1000
219	Mercer, Pennsylvania	Cooper-Bessemer GMV-10	6	1100
214	Carrollton, Ohio	Ingersoll-Rand KVG-123	6	1320

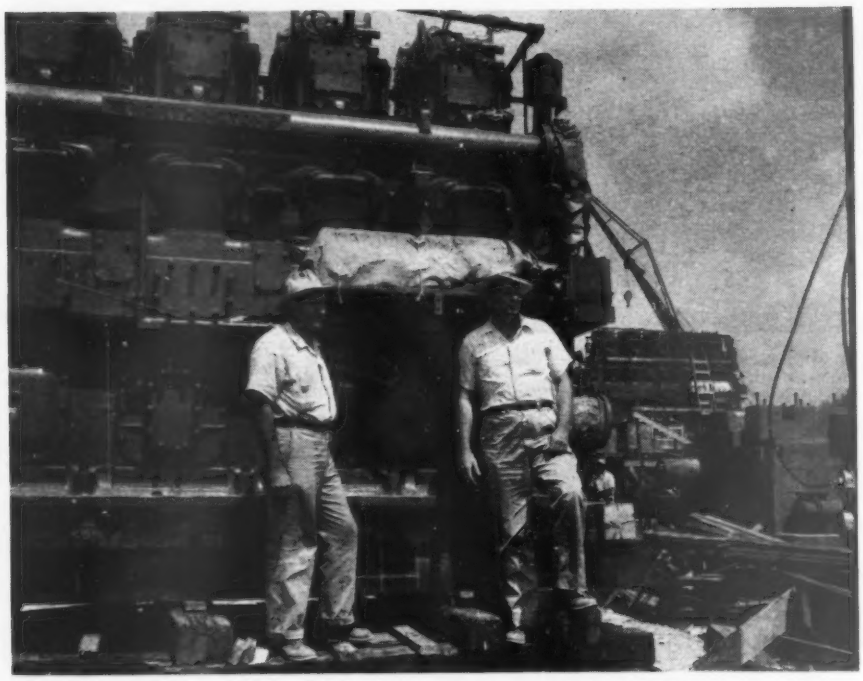
TABLE 2. Additions to stations on Tennessee Gas System.

Station number	Location	Type of units	Number of units	Horsepower per unit
0	Agua Dulce, Texas	Worthington UTC-168	4	1600
1	Victoria, Texas	Cooper-Bessemer GMW8	2	2000
2	East Bernard, Texas	Worthington UTC-168	1	1600
4	Jasper, Texas	Worthington UTC-168	1	1600
5	Natchitoches, Louisiana	Cooper-Bessemer Type 26	2	1600
6	Monroe, Louisiana	Worthington UTC-168	2	1600
7	Greenville, Mississippi	Clark HBA-6	2	1320
8	Batesville, Mississippi	Cooper-Bessemer GMW8	3	2000
9	Middleton, Tennessee	Clark HBA-6	2	1320
10	Lobelville, Tennessee	Cooper-Bessemer GMW8	4	2000
11	Portland, Tennessee	Cooper-Bessemer GMW8	3	2000
12	Campbellsville, Kentucky	Cooper-Bessemer GMV10	6	1100
13	Winchester, Kentucky	Clark HBA-6	5	1320
200	Load, Kentucky	Clark HBA-6	3	1320
204	Albany, Ohio	Clark HBA-6	2	1320
209	Cambridge, Ohio	Cooper-Bessemer GMV10	3	1100

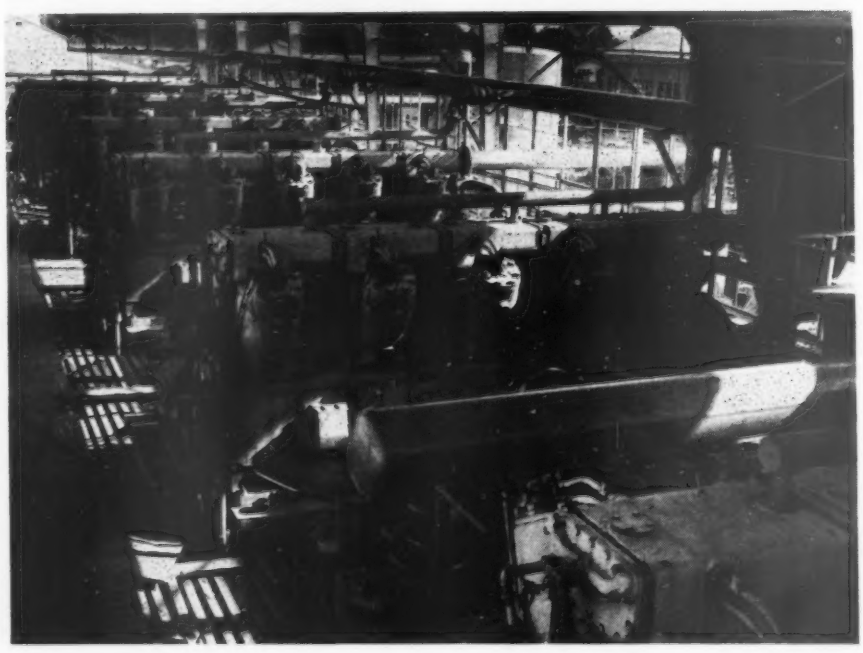


Seams of 90-deg "L" are examined by TGT workmen at West Winfield. Line is part of jacket water cooling system.

Main compressor building at West Winfield, New York, partially completed.



Standing atop the wooden cribbing that supports one of the engines being installed at Nassau, New York, are H. J. Flammang, left, inspector, and B. F. Walden, station superintendent, both TGT men.



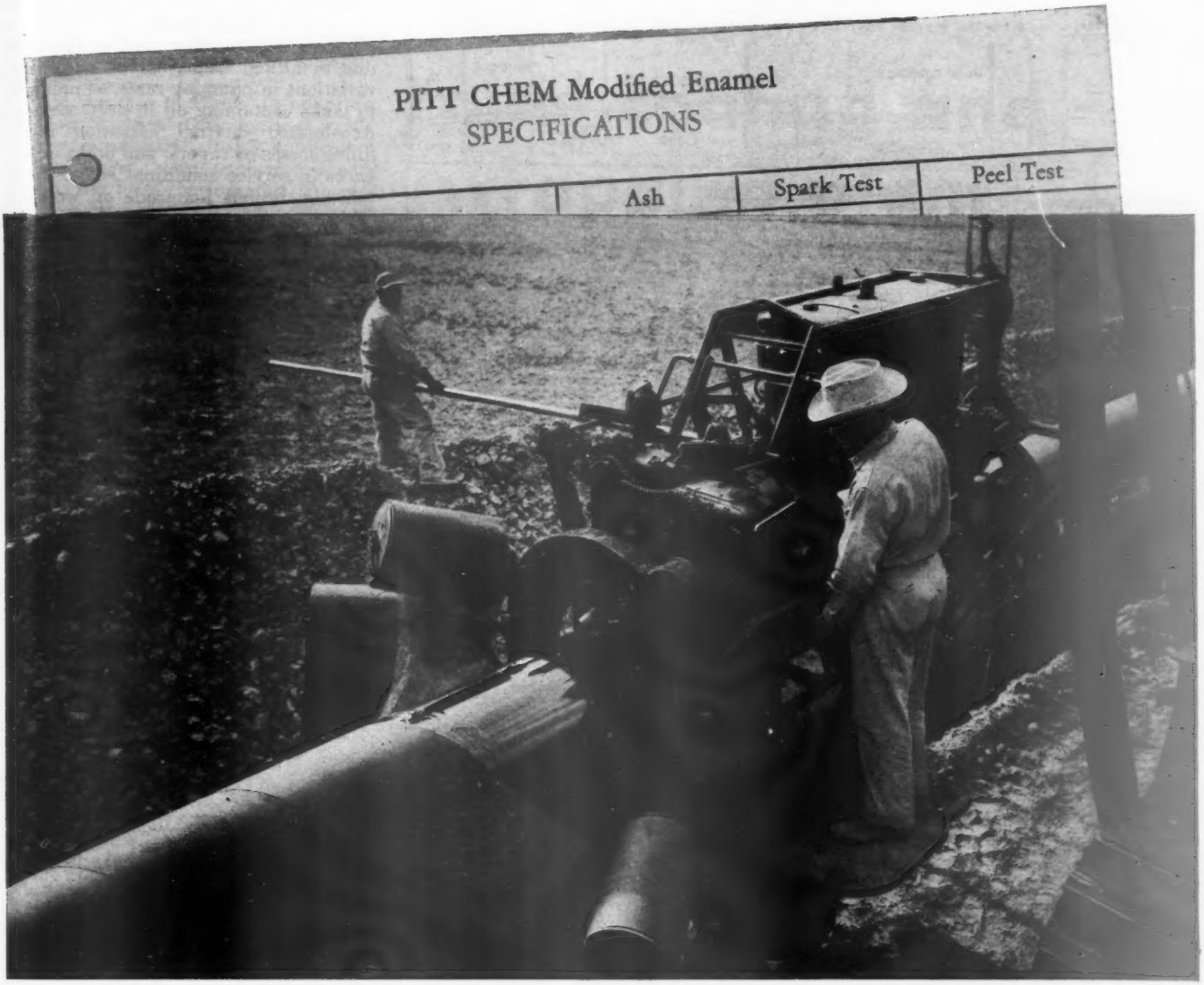
Mercer, Pennsylvania, station houses six 1100-hp compressor units.

the lower ground temperature and lower compression ratio compared with stations farther south. In fact, there is no cooling of gas at any station from Load Kentucky, north.

All engines, auxiliary and main compressor engines alike, have their jacket water cooled by means of atmospheric-type coolers. These units are unusual in that they have variable-pitch fans that are controlled by the outlet temperature of the coolers, which results in maximum efficiency for minimum horsepower. As an example, under conditions that would require 180 hp, with this arrangement only about 30 hp would be needed. The cooling system is unusual in another respect also, a single system with only one set of pumps being used for both jacket water and lube oil cooling.

In keeping with its progressive policy Tennessee Gas is installing telemetering equipment to remotely operate and control gas flow at seven metering stations in West Virginia and Kentucky, as well as to control remotely at Springfield, Massachusetts, the flow of gas from Tennessee's system to its affiliate, the Northeastern Gas Transmission Company. Here again the set-up differs from the conventional in that measurement of gas is effected by controlling differential rather than pressure.

In addition to the equipment already mentioned, each of the new stations has a field gas meter building, office building, a combined warehouse, shop, and change building, equipment garage, a building to house the water treating equipment, gas scrubbers, 2000-bbl water storage tank, elevated domestic water storage tank, starting air bottles, lube oil storage tank, and cottages for station personnel. Twenty-five employee dwellings were erected at the four locations, making 40 in all or 10 at each. These residences have full concrete basements and central gas heating. Generating equipment at Carrollton, Mercer, and Nassau consists of three 370-hp gas-engine-driven generator units, and at West Winfield two 370-hp units. * *



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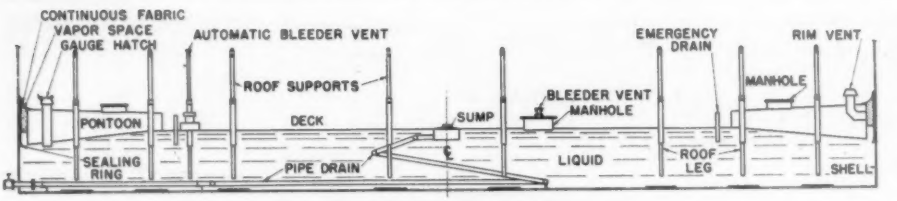
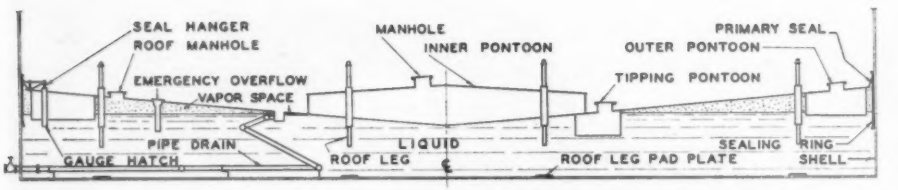
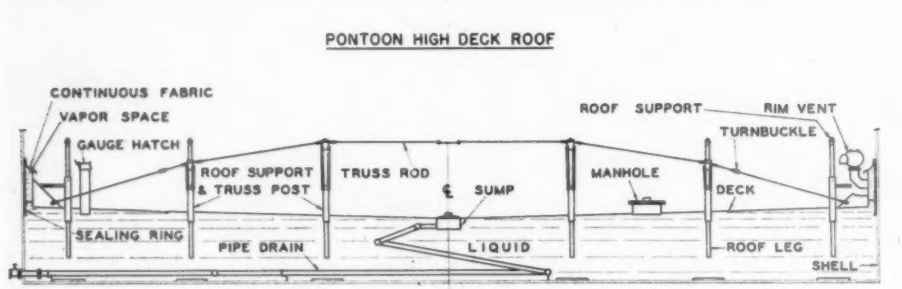


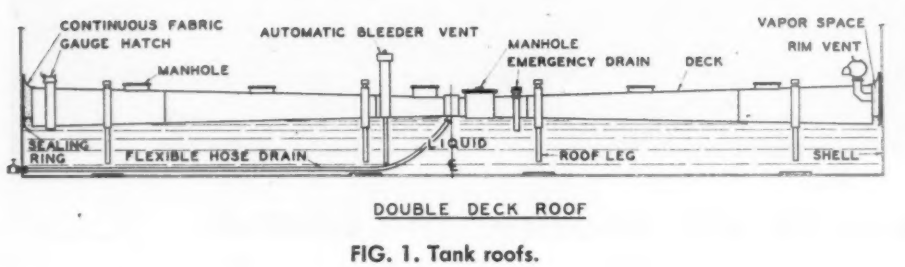
PONTOON LOW DECK ROOF



PONTOON HIGH DECK ROOF



PAN ROOF



DOUBLE DECK ROOF

FIG. 1. Tank roofs.

Crude Oil Working Tanks†

Design, construction, operation, maintenance considerations as applied to pipe line use

R. M. CARTER*

Of the many interesting problems connected with large oil tanks, the most outstanding from a user's viewpoint are those related to utility and serviceability. Operating and maintenance considerations motivate the user's interest in design and construction, but the builder also is concerned with these aspects because of his desire to produce tankage that will meet the customer's service requirements. The purpose of this paper is to discuss, from a user's viewpoint, some of the operating and maintenance considerations that are of common interest.

The discussion specifically relates to working tanks on major pipe line systems transporting crude oil. The term "working tanks" as used here refers to tanks at pumping stations in which the oil level is fluctuating most of the time due to filling, emptying, or absorbing variations in pumping rates, as opposed to tanks containing oil in dead storage. Accelerated internal corrosion rates, filling losses of vapors, and other differences in service conditions suggest certain conclusions for crude oil working tanks that may not hold true for oil storage tanks, or tanks handling other liquids.

Selecting Tank

When a pipe line operation indicates that a tank of a given capacity should be provided, the problem arises of selecting a type of structure and accessories that will measure up to the service conditions imposed. The nature of the crude oil to be handled plays an important part in this selection, particularly the corrosive elements it may contain and its volatility.

Naturally, the selection should proceed by process of elimination from the cheaper to the more expensive. The conventional cone roof should, therefore, be considered before passing it up for the more expensive, but generally more suitable floating roof.

A tank equipped with a fixed cone roof has several disadvantages for oil pipe line use. Among those normally present are high evaporation losses from breathing and filling, and the possibility of undergoing severe damage from stresses accidentally imposed by even the slightest of pressures or vacuums. There is also the probability that a fire, once started, will end in complete destruction of the tanks and contents.

There may be economic situations wherein the initial cash saving to be realized in choosing the cheapest tankage available may outweigh these objections—so long as sweet crude only is to be handled; but where sour hydrogen sulfide-bearing crudes are to be handled, or probably will be handled, it becomes practically imperative to select a floating roof of some kind if reasonable service life with minimum maintenance is to be obtained.

The presence of hydrogen sulfide in crude oil vapor, even in low concentrations, causes very rapid corrosion of continually exposed steel surfaces. A tank with a fixed-position steel roof may have as much as one-third of its total internal surface area exposed to this corrosion, whereas an open-top tank with a floating roof usually has only the rim-plate and sealing mechanism around the edge of the roof subject to attack. The amount of corrosion damage is, of course, proportional to the amount of area exposed. Surfaces wetted by the oil are not damaged by this kind of corrosion.

Pipe line working tanks with steel cone roofs have failed within three years after being placed in sour crude service. Failures are evidenced by pitting and general weakening of the top ring of the shell, roof-deck plates, and roof-supporting structure. Collapse of the roof is the ultimate result. The attack is more rapid on working tanks than

†Presented before the Petroleum Mechanical Engineering Conference of the American Society of Mechanical Engineers, Kansas City, Missouri, September 24, 1952.

*Tank superintendent, Service Pipe Line Company.

on tanks used to store crude, probably because frequent filling and emptying refreshes the hydrogen sulfide content and admits fresh moist air to accelerate corrosion.

If it becomes necessary to adapt an existing fixed-roof tank for sour crude service, a protective coating application on those internal areas exposed to vapors may be worthy of consideration. To date, however, such coatings have not proved very dependable. When building new tankage for sour service, it is better economy to invest in a floating roof than buy the cheaper cone roof and attempt to protect it with a coating.

If an open-top tank is decided upon, operations may be further benefitted by making a considered choice from the several general types of floating roofs available. The more common types are referred to as the "Pan," "Pontoon," and "Double-Deck." (See Fig. 1)

Of the three types, the double-deck has the greatest number of desirable features; also the highest cost. It is most likely to be suitable for any operating requirement that may develop. On the other hand, there are conditions under which the cheaper roofs may be expected to give satisfactory service, and considerations should be given to the initial cost saving afforded by their use.

If sour crude service is anticipated, a floating roof should be of a type having a minimum of steel surface exposed to gas and a maximum area in contact with the oil in order to have the least trouble from hydrogen sulfide corrosion. The pan roof satisfies this requirement as well as the double-deck, as does also the pontoon roof of the type having a low deck in full contact with the oil. The high-deck type of pontoon roof has a large under-deck area, which rides out of the oil and, therefore, is exposed to hydrogen sulfide corrosion. This roof is not as desirable as the others for sour crude service because of the difficulties encountered in maintaining coatings on the larger vapor-exposed areas. Experience has shown that the rate of corrosion is more rapid on horizontal surfaces exposed to vapors, such as the underneath side of this deck, than on the vertical areas of the rimplate.

In the handling of crudes, or crude-casinghead mixtures, having vapor pressures approaching the limit for atmospheric pressure tankage, the insulating properties of a roof become important. Passing lightly over a matter that in itself is a subject worthy of considerable study, may it suffice to say here that the double-deck roof is the better structure in this respect. If it becomes necessary to apply additional insulation, the weather-protected space between decks at least provides an ideal place to put it and permits the consideration of a greater variety of insulating materials. The pontoon roof also has inherent insulating qualities, while the pan has practically none and is difficult to insulate in a serviceable manner.

A frequently voiced objection to pan roofs is lack of stability under water and snow loads. Actual experience in operating 70 pan-type roofs without any of them ever having been sunk in the oil,

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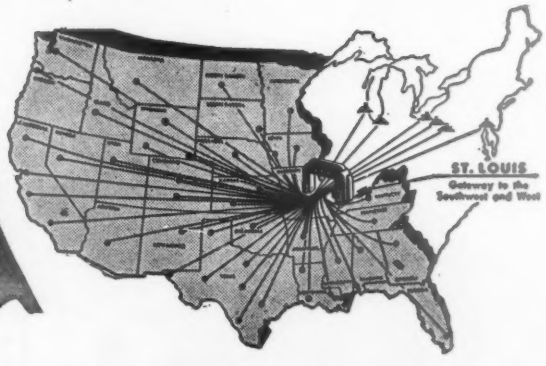

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even though 17 of them were in service as far back as 1931, would indicate that this inherent fault can be coped with and need not stand in the way of their selection if other factors are favorable. Recent design changes improving the general appearance and facilitating maintenance, coupled with the economies of cheaper construction, have made the pan-type roof very attractive.

Rimplates On Sour Crude Tanks

Although a floating roof of an appropriate design is immune to an extensive attack by hydrogen sulfide corrosion, it may still have some vulnerable points of minor nature that require special attention. Among them are the outer rim of the roof and the parts that make up the sealing ring mechanism; in other words, all surfaces that are exposed to gas in the annular space enclosed by the continuous seal fabric between the sealing ring shoes and the vertical rimplate of the roof proper. On a 120-ft diameter tank the rimplate has an exposed area of some 900 sq ft.

It has been suggested that the rimplate be made of non-ferrous metal or corrosion-resistant steel. Actual service experience indicates that the use of slightly heavier steel plate, 5/16-in. or ¼-in. instead of the usual 3/16-in., will adequately strengthen this part at little added expense and without complicating erection methods.

The continued use of steel plate in the rim should be accompanied, however, by good maintenance practices. The vapor-exposed surface should receive a protective coating at the time interior coatings are applied to other parts of the tank. It is essential also that the continuous seal fabric be kept in good repair to keep fresh, moist air out of the annular gas space. Corrosion has been found to be accelerated in the vicinity of breaks in the fabric.

Galvanizing has proved to be a practical and effective method of protecting the sealing ring sections or shoes. Small parts such as hangers, linkage, brackets, etc., either should be galvanized or made of heavier than usual stock to offset corrosion. Small pivot pins and cotter keys should be made of stainless steel. Some sealing ring designs have mechanisms in the gas space under the seal. If the mechanical parts thus exposed to sour gas are treated according to the foregoing suggestion, corrosion damage should not be severe enough to stand in the way of acceptance of the design.

Cleanout Doors

At one time or another during the life of an oil tank it probably will be necessary to clean thoroughly the bottom and eliminate explosive vapors so that welded repair, interior coating, or alteration work can be performed. Changes in the grade of crude handled and loss of working space also may necessitate internal cleaning. In the older tanks of riveted construction, access to the interiors is readily obtained by removing one of the lower shell sheets, the joints of which may be parted safely by cutting the rivets with an air-driven chisel. This provides a large opening nearly flush with the bottom through which the heavy bottom settlings may be removed without interfering with the dragging method commonly used.

The welded shell in modern construction presents a problem in providing a satisfactory cleanout opening. The removal of a shell sheet by flame-cutting is, of course, impossible prior to cleaning; furthermore, rewelding of shell sections should be kept to a minimum to avoid distortion stresses. In the early forties, an attempt was made to solve the problem through the use of a cover plate bolted to a square, framed opening in the shell, fabricated of flat plate sections with welded joints and sharp corners. Faults in this device were eventually brought to light by a failure resulting in complete destruction of a 90,000-bbl tank and its contents. The severity of this accident, which attracted industry-wide attention, naturally resulted in a more cautious attitude toward bolted cleanout doors of any sort. The fact remains that there is a definite need for a removable cleanout door for welded tanks, particularly one with the opening flush with the bottom, and it is hoped that an improved design may be proved worthy of general acceptance. New designs developed by the major tank companies are now under consideration by the American Petroleum Institute.

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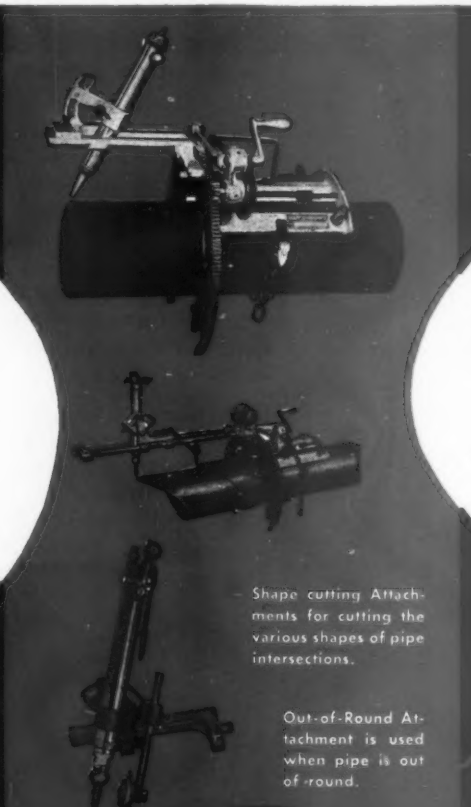

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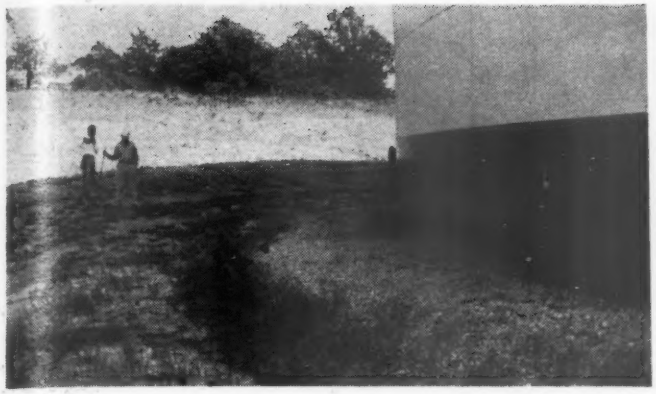


FIG. 2. Crushed rock base-well drained.

FIG. 3. Poor grade preparation.

Bottom Sumps

Development of a bottom sump design usually includes sloping the bottom to the sump for drainage, connecting the suction and filling lines directly to the sump, and leading them out from under the tank below the bottom plates. If the tank is to have a floating roof, some sort of arrangement is also necessary for the roof to be operated to the extreme low position in contact with the bottom.

The objectives are: (1) Use of the full capacity of the tank as working space, and (2) prevention of BS&W accumulation. Although the objectives are very worthy, this route of approach to them should be taken only after thorough consideration is given to the operating and maintenance characteristics involved. Otherwise, one may end up with a facility that is a liability instead of an asset, or does not serve its intended purpose.

As to the working space consideration in a tank feeding the main line pumps, it is impracticable to draw the oil level down below the minimum head that will remove oil through the suction line system and fill the pumps at the rates demanded by the pumping schedule. When the minimum head pressure is reached, it is necessary to switch to a fuller tank as reduction to a lower pumping rate usually is not desirable, particularly since the primary objective is operation at full line capacity. Minimum working levels lower than 3 or 4 ft are rather uncommon under conditions prevailing on large-capacity pipe lines. Even when favored with a high tank grade elevation, or using booster pumps in the suction line, a minimum level of two feet may be difficult to obtain due to cavitation, line restrictions, etc. Unless a spare pump-down unit is available, or its use justified, to continue reducing the tank at a low rate, the oil left below the working level will remain in dead storage. It follows then that before attempting to convert the extreme lower levels of a tank into working space, one should check related facilities to ascertain that the space would be used as such if available.

Effective control of BS&W accumulation is, of course, a major problem in pipe line operations, but it is the BS that builds up into the working space of a tank that is of the greatest concern. BS occupying the normally dead space in the extreme lower levels of a working tank is of less concern; there is little need to remove it except infrequently to thoroughly clean the tank for repair, retirement, or to change to an entirely different grade of crude, such as from a sour to a sweet crude or from a paraffin base to an asphalt base crude. In fact, bottom settlings appear to have been beneficial in some instances by sealing off holes developed from bottom-side corrosion and acting as a buffer against internal corrosion. Top-side corrosion of uncoated bottom steel is usually worse in areas continually swept clean by the incoming stream.

Where the minimum working level, as previously defined, is 2 ft or more above the bottom, practical BS control can be obtained by using a rigid suction line with its inlet end turned downward or terminating in a vortex chamber, and accompanied by some sort of a liquid agitating device to keep the BS leveled off at the height of the suction inlet. Agitation can be accomplished with a motor-driven propeller-type mixer, or under certain conditions with a jet system using the force of the incoming stream.

Our greatest task in maintaining oil tanks is to combat corrosion, internal as well as external. With conventional construction we can do a fair job of preventing bottom leaks through the use of galvanic anodes, good drainage of the grade, and application of bottom coatings. Installation of bottom sumps and lines under the bottoms would certainly increase the obstacles to be overcome in this battle because of the inaccessible surfaces subject to corrosion on which it would be practically impossible to maintain protective coatings. Lines extending under the bottoms of tanks would also be inaccessible for repairing failures in the connections that occasionally result from uneven settling and other causes.

Tank Grades

The effort required to obtain and maintain a properly designed and well-constructed grade for a tank will pay big dividends throughout the years in operating problems avoided. Such a grade is expected to provide a uniformly level and stable surface on which the erector can build a truly round, level, and plumb tank. It is expected to offer reasonable assurance that the completed tank will continue to be supported in its original shape, that normal settlement will be uniform and minimized, and that the underneath surfaces of the tank bottom will be kept dry to mitigate bottom-side corrosion. Soil conditions and the lay of the land may determine the amount of effort required to accomplish these things.

Obtaining good drainage at the start is usually a routine job of grading the ground around the tank site; also avoiding the ancient practice of cutting the grade below the surrounding terrain in order to supply dirt for the firewall. In conjunction with a suitable means of disposing of surface water, a uniform pad of crushed stone 6 in. thick placed on the tank base proper will suffice to keep the bottom steel dry by aerating it and preventing the capillary attraction of moisture. Figs. 2 and 3 are typical examples of good and poor grade preparation for proper drainage.

For the smaller tanks up to 80 ft in diameter by 40 ft high built on ordinary soils, a well-graded base padded with crushed stone probably will be adequate. In some instances the same type of base may also be adequate for tanks up to 120 ft diameter by 56 ft high where naturally compact soils are encountered in a dry climate, such as in West Texas; but generally, it is good practice to add a concrete ring to the base of the larger tanks.

Concrete Rings

There is a wide variety of applications for concrete rings, ranging from those locations where tanks definitely could not be built and operated without them, to those where soil conditions are good, but construction and maintenance could be helped materially by adding the rings. At the low end of the range where the worst conditions prevail, the ring design must follow the common practice of designing to withstand ultimate bending stresses and hoop stresses calculated on the assumption the soil is a fluid.

The heavily reinforced concrete construction resulting from this design approach is too expensive, however, for the other end of the range where the less obvious benefits to be gained naturally

FIG. 4. Erosion of unprotected earthen base.

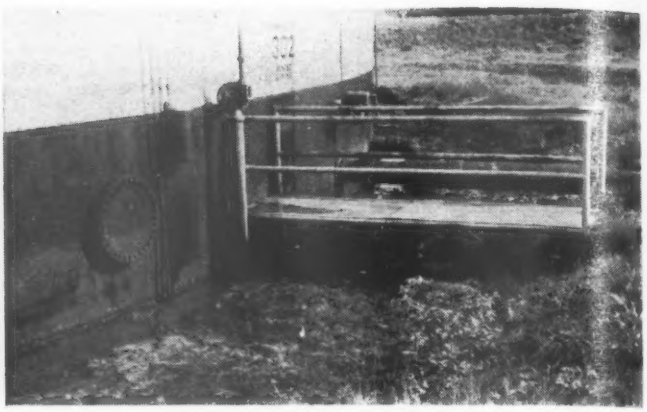
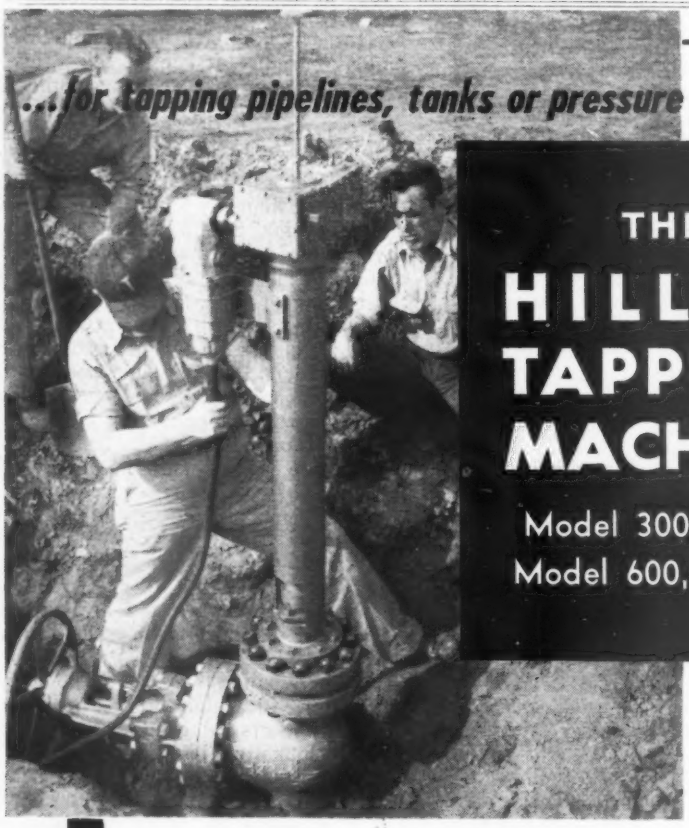


FIG. 5. Wet soil in poorly drained earthen base.



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attract closer attention to the reasons for requesting an appropriation. For these less exacting uses, one should propose a simple design sized only to compensate for the unbalanced weight of the shell, with only the minimum steel required to resist vertical shear, and with no regard to assumed bending and hoop stresses.

To illustrate the point, it would be well to mention some of the less obvious advantages of concrete rings that can be gained through relatively light construction, where conditions warranting the more expensive, fully designed ring do not exist. Actually, in the pipe line business, by far the greater number of tanks are built where soil conditions are average to good.

It has been observed when inspecting the interiors of many old tanks, even those on good soil, that the outer 2 ft around the edge of the bottom is usually sloped sharply downward. The lower edge of the shell, or chime angle, may be 4 to 5 in. lower than the average bottom elevation, thus placing unnatural stresses in the bottom and shell plates. Settlement of the shell below the bottom level in such cases is caused by the concentrated weight of the shell coupled with one or more of three things acting on the soil supporting it: (1) erosion by wind and water; (2) alternate freezing and thawing, and (3) alternate wet and dry conditions. Each time the top layer of soil is softened by thawing or soaking, a little of it is squeezed out from under the edge of the tank. Several years may be required to develop the observed condition. The fact that the bottoms usually are nearly at their original level, except for having been pulled down around the edge by the weight of shell, indicates that the soils are able to support the oil loads with no appreciable lateral displacement, but need a little help in suporting the shell loads. Figs. 4 and 5 show soil erosion and wet soil conditions that contribute to tank settling.

In considering a new installation subject to similar conditions, it becomes obvious that what is needed most is to substitute a solid material such as concrete in the perimeter of the base to prevent erosion and retain firmness there when thawing or wet. Furthermore, the soil pressure under the shell should be

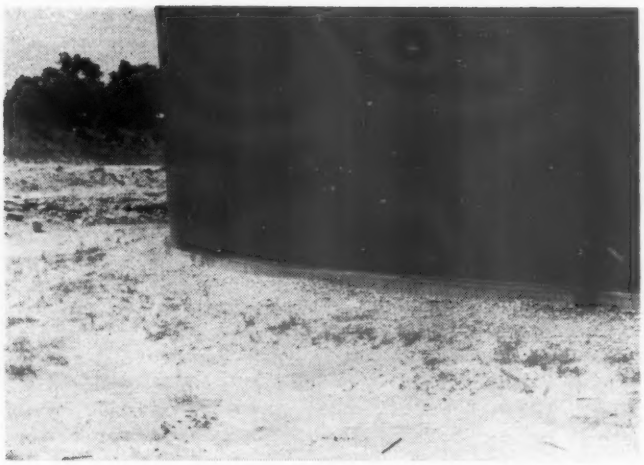

FIG. 6. Concrete ring installation.

reduced and in doing so, it is advisable to design for a uniform pressure over the entire base, with the concrete ring considered as an integral part of the tank. Only that part of the ring which extends beyond the edge of the tank adds bearing surface to counteract the shell load. As an example, for a 120-ft diameter by 56-ft high open-top tank having a shell weight of about 1400 lb per foot of circumference and a maximum oil load of about 2800 lb per square foot, a concrete ring 1 ft wide with the shell resting on the center of the section would produce for all practical purposes the balanced loading condition desired. A depth of 12 to 18 in. of concrete should be adequate. Fig. 6 shows a concrete ring installed under a 167,000-bbl tank.

A concrete ring can be poured and finished off accurately enough to provide a true plane surface on which to erect the tank shell without resorting to shims for leveling the first ring. Furthermore, the base will stay level as the erection progresses from ring to ring, thereby avoiding the necessity of releveling during construction as is so often the case without rings. This feature is important to the erector in his effort to produce the best possible job, which in turn is most important to the user because a well-built tank is one of the first prerequisites to trouble-free operation.

A concrete ring facilitates maintenance of the grade. As the vertical face of the concrete ring need not be protected against erosion, more variation is permissible in the surface level of the grade around the tank; consequently, less frequent attention is required than is the case where a grade has to be maintained at the exact level of the tank bottom. For the same reason the lower extremities of the shell can be kept clean and protected from corrosion.

Conclusion

As previously stated, one prerequisite for trouble-free operation and low maintenance is a well-built tank. Others are proper selection of type and inclusion of those design features specifically indicated for the service conditions anticipated. Decisions on these matters will be the more sound when founded on actual experience, provided the experience is properly interpreted and correlated with the problem at hand. Inasmuch as an individual's opportunities to gain sufficient experience to cope with any eventuality are limited by time, it would be helpful to have a pool of everyone's experiences on which to draw. The foregoing conclusion is offered, therefore, with the thought in mind that it may be of value for consideration along with our own experiences and judgment; it being understood that different conclusions could be drawn from different circumstances. * * *

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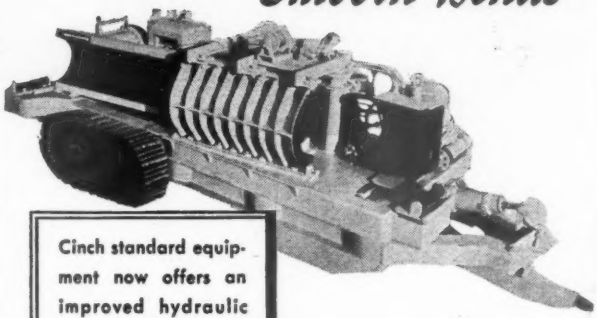

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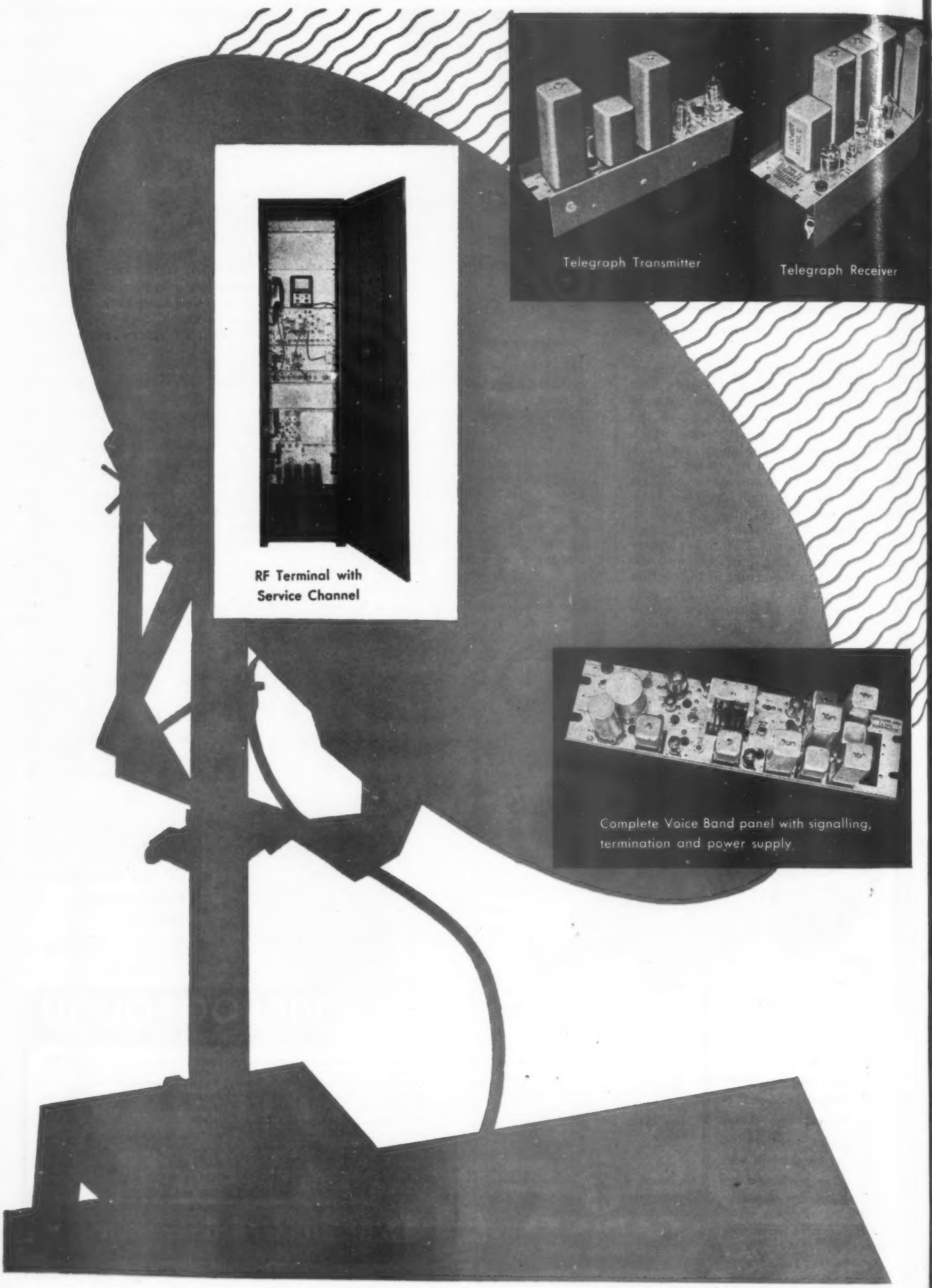
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Booster Stations Being Constructed in California

In connection with the construction of two booster stations at Desert Center and Cactus City, on the California section of the Texas pipe line, jointly owned by Southern California Gas Company and Southern Counties Gas Company, two 34-ton valve assemblies were recently installed.

Each of these consisted of 30-ft sections of 30-in. pipe line with connecting tee joints and a 1000-lb Nordstrom valve. They were required to provide access to the compressor stations, now under construction.

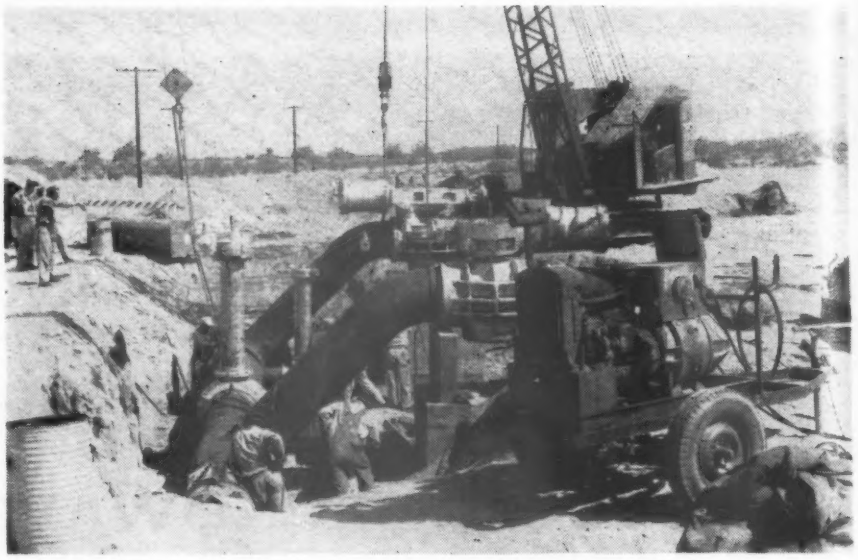
Work on the two booster stations is proceeding on a separate job basis. J. B. Gill Company has been awarded contract for excavating, grading, and installation of concrete and underground utilities. Other contracts, covering erection of buildings, installation of machinery and piping, electrical work, and painting will be let when the concrete job has been completed.

In addition to the compressor capacity, which will be provided by the two compressor stations under construction, another 3520 hp will be added at the Blythe station, with installation of two 1760-hp Clark compressors. This project is expected to be finished early in 1953.

Meantime, work will be begun immediately on the laying of 14 miles of 30-in. loop line from Whitewater, near Palm Springs, east, paralleling and eventually tieing in to the present Texas line. A similar 6.3 miles of loop line will also be constructed from the Blythe compressor plant to the Colorado River.

Completion date for the 14 mile loop west of Indio has been set for early February and for the loop feeding the Blythe station, March 1 has been set as the completion date.

Cost of the total new construction to the two companies is estimated at slightly in excess of $5,000,000.



Valve assemblies, weighing 34 tons each, were installed in the California section of the Texas pipe line at Desert Center and Cactus City.

Sinclair Starts New 85-Mile Products Line

Construction has begun on the first section of a new 12-in. products pipe line of Sinclair Pipe Line Company, to extend 85 miles from Sinclair's Houston, Texas, refinery to Port Arthur. The first section will comprise 40 miles of line.

The new 12-in. line, which will have a capacity of 54,000 bbl a day, will connect near Port Arthur with the 16-in. Evangeline Line now under construction between Port Arthur and Baton Rouge, Louisiana.

Estimated to cost $3,000,000, the new Sinclair products line will be completed on March 31, 1953. Company officials stated that the new line will eliminate a "bottleneck" in transportation in the area served, and will represent a substantial contribution to national security.

J. L. Seger Heads Pipe Line Committee

The Committee for Pipe Line Companies, composed of crude oil and products pipe line carriers of the United States, elected officers at its semi-annual meeting in New Orleans, Louisiana, as follows:

Joseph L. Seger, Interstate Oil Pipe Line Company, Shreveport, Louisiana, chairman; L. H. True, Magnolia Pipe Line Company, Dallas, Texas, vice chairman, and Paul J. Bond, Pure Oil Company, Chicago, Illinois, treasurer. Gordon C. Locke, Washington, D. C., was re-elected executive secretary and associate counsel, and Fayette B. Dow also of Washington was re-elected general counsel.

The newly elected officers of this committee will serve during the calendar year 1953.

First Quarter Steel Allotments 256,500 Tons

Seven major natural gas pipe line projects and one major gas underground storage project have been given priorities assistance for the purchase of line pipe for the first quarter of 1953, Acting Deputy Petroleum Administrator C. E. Davis announces.

Total estimated construction cost of the eight projects is $323,078,000 and they were allocated 140,100 tons of pipe for the first quarter.

In addition 116,400 tons of pipe have been allocated to 450 smaller projects, including gathering lines, distribution lines, other facilities, and MRO (maintenance, repair, and operations).

Total pipe allocated to date for the quarter is 256,500 tons.

Details of the major projects given priorities assistance are the following:

	Estimated cost	Estimated completion date	Capacity cu ft/day	1st Q line pipe required
United Fuel Gas Company				
Underground gas storage	$ 8,150,000	4Q53		6,760 tons
Pacific Gas & Electric Company				
Loop lines and comp. hp	5,944,000	3Q53	50,000,000	12,961
Loop lines	10,947,300	2Q53	100,000,000	191
The Texas Company				
Transmission lines	3,933,000	3Q53	35,000,000	11,714
El Paso Natural Gas Company				
Loop lines	63,732,960	2Q53	200,000,000	500
Southern Natural Gas Company	77,675,600	1954	350,000,000	72,153
Texas-Illinois Natural Gas Pipe Line Co.				
Comp. hp & lateral lines	21,940,000	3Q53	50,000,000	2,231
Tennessee Gas Transmission Company				
Loop lines & comp. hp	130,755,590	4Q53	405,000,000	33,790
Total major projects	$323,078,450		1,190,000,000	140,100
Other projects				116,400

Q—Quarter.

Steel Made Available for Extension of Interprovincial

T. S. Johnston, president of Interprovincial Pipe Line Company, has confirmed that allocation of steel has been made by the Petroleum Administration for Defense in Washington to provide for extension of the Interprovincial system from Superior, Wisconsin, to Sarnia. Johnston pointed out, however, that decision to proceed with the project will depend entirely upon satisfactory financing arrangements.

If built the line extension would be 625 miles long and of 30-in. diam. Initial capacity into Sarnia would be 85,000 bbl a day but by installing additional pumping stations this could be brought up to more than 300,000 bbl if required. The existing Interprovincial system would then have to be enlarged to meet the anticipated throughputs into Sarnia.

The route of the extension would be across northern Wisconsin and Michigan to the Mackinac Straits and then south through Michigan to a crossing on the St. Clair River near Sarnia, Interprovincial Pipe Line reported.

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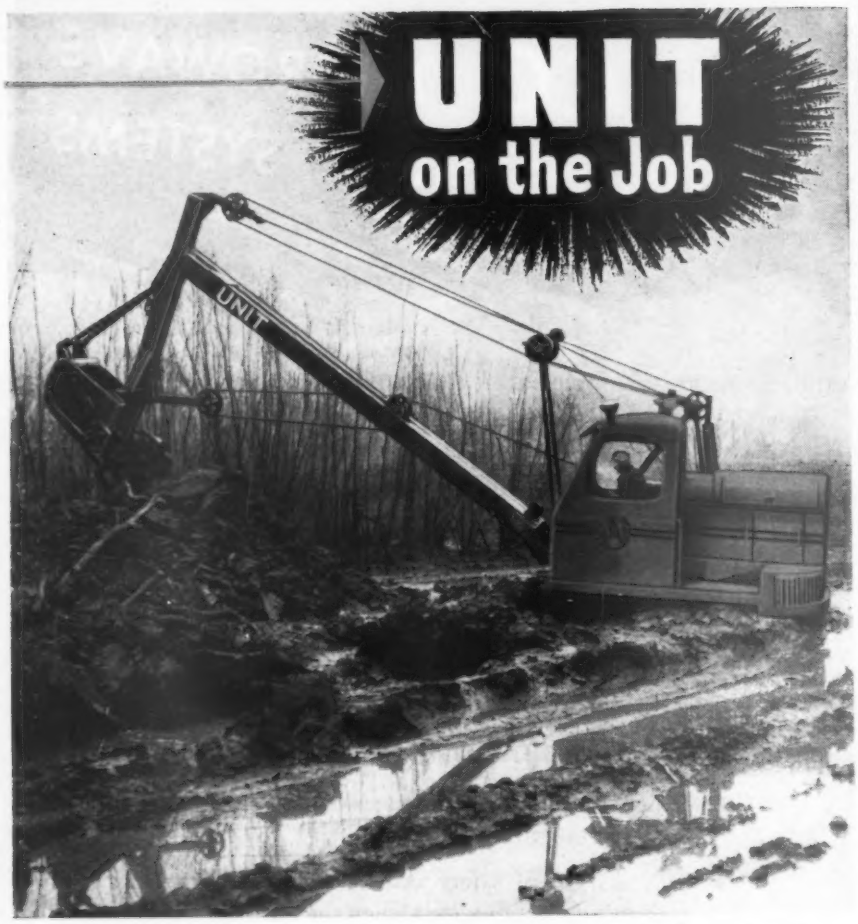

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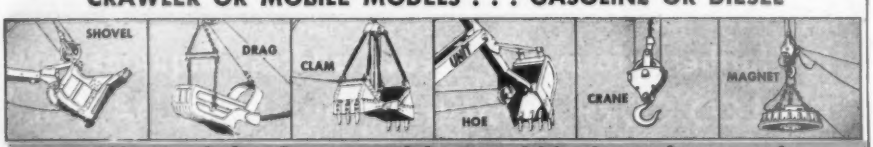

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News

Buckeye Pipe Line Completes First Section

The Buckeye Pipe Line Company will soon place in operation the first section, from Linden, New Jersey to Allentown, Pennsylvania, of its new $24,000,000 Eastern Products Pipe Line System. This leg of the line consisting of 16-in. pipe will move refined petroleum products for a number of oil companies from Linden, one of the largest refining centers on the East Coast, to Allentown, Pennsylvania. All 16-in. pipe has been laid and the Linden pump station is scheduled to be finished early in February. Near Allentown, a junction will be made with The Tuscarora Pipe Line Company for trans-shipment to terminals west of Allentown through Harrisburg as far as Pittsburgh.

The final section of this Eastern System is scheduled for construction in 1953. A 14-in. line will run from Allentown through the Scranton-Wilkes-Barre area to Binghamton and Auburn, New York. A 10-in. line will run from Auburn east to Syracuse, New York, and another 10-in. line from Auburn west to Caledonia, New York. At Caledonia, a connection will be made with the existing lines of The Buffalo Pipe Line Corporation permitting transportation to terminals at Rochester and Buffalo, N. Y.

The National Tube Company will begin delivery of the 14-in. pipe in January, and has scheduled the 10-in. pipe for the balance for April and May.

Natural Gas Department AGA Ceases to Exist

The Natural Gas Department of the American Gas Association has ceased to exist as a separate division, in accordance with the revised Constitution and By-Laws, approved by a majority of AGA members. The Manufactured Gas Department also goes out of existence. A special committee appointed to study the AGA organization considered the breakdown of the association into the two departments is no longer necessary or advisable, in view of the tremendous expansion of the nation's transmission network and the spread of the use of natural gas until it represents 92 per cent of all the gas sold in the United States.

Film Made Available On Marine Crossings

The problems attendant to marine pipe line crossings provided the background for a 20-minute film, entitled "Herman Hevicote," recently released by the H. C. Price Company of Bartlesville, Oklahoma. This film, combining live photography and animation, was shot in full color and is accompanied by both music and narration. The picture points up the uses for Hevicote, a concrete-type jacket placed on pipe lines at marine crossings for purposes of giving weight and affording protection. Showings of the film can be arranged by addressing requests to H. C. Price Company, P. O. Box 1111, Bartlesville, Oklahoma.

First Quarter Allocations for Oil Pipe Lines

Six large crude oil pipe lines and eight large petroleum products pipe lines, with a total construction cost of $595,698,000, have been given priorities assistance by the Petroleum Administration for Defense for the purchase of 222,896 tons of line pipe during the first quarter of 1953.

In addition a number of smaller projects have been given priorities aid by PAD for the purchase of 11,457 tons of line pipe during the quarter.

Allocations for the first quarter to date total 234,353 tons.

Among the major projects receiving priorities assistance for the first time are the following two crude and three products lines:

A 45-mile 12-in. crude line to be built by Phillips Pipe Line Company from Missouri City to Sweeny, Texas. The line, with an initial capacity of 35,000 bbl a day, is estimated to cost $1,851,000 and to be completed in the third quarter of 1953.

A 55-mile 10 and 12-in. crude line to be built by Gulf Refining Company from Bay Marchand to Plaquemines, Louisiana; initial capacity, 50,000 bbl a day; estimated cost, $3,195,000; estimated completion, second quarter 1953.

A 103-mile 6-in. products line to be built by Cal-Ore Pipe Line from Crescent City, California, to Medford, Oregon; initial capacity, 8000 bbl a day; estimated cost, $2,272,000; estimated completion date, fourth quarter of this year.

A 66-mile 10-in. products line to be built by Phillips Pipe Line Company from Brookshire to Sweeny, Texas; initial capacity, 25,000 bbl a day; estimated cost, $1,985,000; estimated completion date, third quarter of 1953.

A 243-mile 10 and 12-in. products line to be built by Standard Oil Company (Indiana) from Whiting, Indiana, to River Rouge, Michigan; initial capacity, 49,000 bbl a day; estimated cost, $11,544,700; estimated completion date, fourth quarter of 1953.

PAD also has granted first-quarter 1953 priorities assistance for a 625-mile 26-in. crude line to be built from Superior, Wisconsin, to the international boundary near Sarnia, Ontario. This project, with an initial capacity of 100,000 bbl a day and an estimated cost of $60,000,000, was granted priorities aid for purchase of 44,600 tons of line pipe in the fourth quarter of 1952. The allocation was made too late for inclusion in the regular PAD announcement of priorities assistance for the fourth quarter of 1952 (PAD News Release 479). Project is scheduled for completion in the fourth quarter of 1953.

A summary of first-quarter allotments for oil pipe lines follows:

	Total cost	Line pipe, tons: Total assistance required	Line pipe, tons: Authorized for 1st Qtr. 1953
6 large crude lines	$206,226,000	514,563	126,269
8 large products lines	189,472,000	396,233	96,627
Total	1395,698,000		
Other small projects— Crude, products, terminals, small construction and MRO			11,457
Totals		910,796	234,353

Radio Equipment for Citizens Band Approved

The Federal Communications Commission recently announced its first specific FCC Class "A" Citizen's Band type approval on mobile and base station radio equipment for operation in the 460-470 mc frequency band. The FCC approval is for mobile and base station equipment manufactured by Motorola, Inc., of Chicago. FCC Type Approval No. CR-406 and No. CR-407 applies to Motorola mobile radio model T44A and base station model L44A respectively, the company announced.

As defined by the FCC, Class "A" operation is within the frequency range from 460 to 462 mc and from 468 to 470 mc and is limited to a transmitter final amplifier power input of 50 watts. Class "B" operation extends from 462 to 468 mc and is restricted to a power input of only 10 watts.

Approval of this equipment opens new channels to all individuals or commercial enterprises who need two-way radio and who were previously ineligible because of FCC regulations. Previously, two-way radio operation was restricted to the 25-50 mc and 152-174 mc bands. Because of the tremendous traffic demands, operation was reserved chiefly for users in the land transportation, public safety, and industrial and domestic public services.

Contract Awarded

Missouri Valley Canadian Ltd., Winnipeg, has been awarded the contract for three crude oil pipe lines running from Burnaby tank farm to Shell refinery at Shellburn, Imperial Oil Limited plant at Ioco, and Trans Mountain loading dock at Barnet on Burrard Inlet, according to an announcement by Canadian Bechtel Limited.

The Shell line will be about 2½ miles in length, Imperial six miles, and Trans Mountain three miles.

Total cost of the three lines will be approximately $1,000,000.

Missouri Valley also has the contract for the major crossing of the Fraser River at Port Mann.

Transmission-Storage Conference of AGA

The first Transmission and Storage Conference will be held April 30-May 1, 1953, at the Edgewater Beach Hotel in Chicago. The conference will take the place of the natural gas spring meeting, which will not be held because the Natural Gas Department was discontinued.

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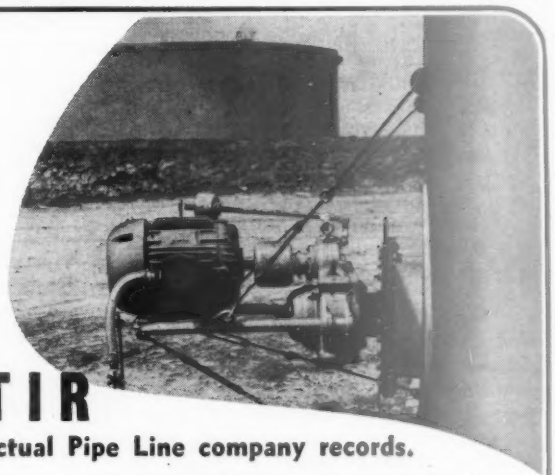
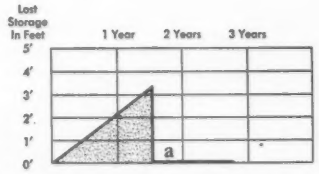


as proven by actual Pipe Line company records.



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Pipe Line Personals

Myrven L. Mead

Myrven L. Mead has been promoted from assistant to the president to vice president of Northern Natural Gas Company. Mead has been with Northern Natural since 1931 and has held distribution, engineering, and sales positions. He was promoted from rate engineer to assistant to the president in 1950.

He was born on a farm near Tobias, Nebraska, and was graduated from the engineering school of the University of Nebraska in 1931.

R. F. Pielsticker will serve temporarily as general manager of crude oil supply and products pipe lines for Standard Oil Company at Chicago during the absence of R. E. Nelson, Jr. Pielsticker is president of Stanolind Oil Purchasing Company at Tulsa, Oklahoma. Nelson, as previously announced, will be granted a leave to join the Petroleum Administration for Defense at Washington, D. C., as director of the supply and transportation division February 1, 1953.

Pielsticker was elected president of Stanolind Oil Purchasing Company in 1951 after 20 years' service with Skelly Oil Company. He was with Skelly's marketing, sales, crude oil purchasing, and pipe line departments at Kansas City, Missouri, and El Dorado, and Wichita, Kansas. In 1941 he was transferred to Tulsa and promoted to executive assistant to W. G. Skelly and manager of pipe lines and crude oil purchasing. He is a graduate of Georgetown University.

Stanley Owens, director of safety for Transcontinental Gas Pipe Line Corporation, told members of the New York Mariners Club recently that modern pipe line companies, especially designed for transmitting natural gas over long distances, have achieved a record of practically 100 per cent continuity of service, and have reduced to a minimum the possibility of breakdowns. He traced the safety features that go into modern lines, from fabrication of the pipe, through the construction period to maintenance during actual operation.

Citing an example of modern construction and operation, he pointed out that Transcontinental, which supplies New York City with natural gas, from the beginning of operations, has not met with a single accident involving injury to the public or damage to public property.

Referring to the insurance of pipe lines, Owens said the experience record on inland marine insurance coverage on pipe lines, aerial bridges, and related construction work had revealed a minimum of losses. He told of a major gas transmission company that, "during a five-year period experienced a loss ratio of zero per cent on extensive combined inland marine and marine insurance."

Owens concluded that when underwriters realize the extent to which today's modern pipe lines are engineered and operated for safety, it follows that the "placement of inland marine and marine coverages on those pipe lines that are primarily designed, built and operated for the transmission of natural gas should prove profitable to the marine insurance underwriting fraternity."

Charles R. Hetherington has been appointed vice president of Westcoast Transmission Company, Ltd., Calgary, Canada. Hetherington, formerly of Ford, Bacon and Davis, Inc., engineers of New York, has been associated for more than three years with Westcoast Transmission's projected natural gas pipe line from Alberta to the Pacific Northwest, when he was engineer in charge of the pipe line design for Ford, Bacon and Davis.

Hetherington, a graduate of Oklahoma University and of Massachusetts Institute of Technology, has spent nearly all his business career engaged in the petroleum and natural gas industry in the refining, petrochemical, and pipe line divisions. He designed the Michigan-Wisconsin pipe line to Detroit, including underground storage of gas in depleted fields, and the Algonquin Gas Transmission Company pipe line to New England. He has also been a consultant for a number of natural gas organizations, including Michigan Consolidated Gas Company, and Southern Natural Gas Company, and for some of these was in administrative charge of pipe line and plant construction. He was also a member of the operating committee of a large underground storage project in Pennsylvania.

He is a member of the American Gas Association, the American Chemical Society, and is a registered engineer in various states and Alberta.

Gilbert V. Rohleder, Service Pipe Line Company, Tulsa, Oklahoma, addressed The Tulsa Pipe Liners Club at its December 15 meeting on the subject "Work Planning—Its Challenges and Limitations."

H. M. Cooley, assistant metallurgical engineer, Bethlehem Steel Company, Company, Tulsa, Oklahoma, spoke on "Effects of Various Metallurgical Characteristics of Steel on Its Resistance to Corrosion" before the North Texas Section of the National Association of Corrosion Engineers at its December meeting in Dallas, Texas.

Waldo Shipman has been transferred from Falls Church, Virginia, to New York City where he is supervisory engineer of the organization and planning department of the Columbia Gas System Service Corporation. Succeeding him as staff engineer for the Atlantic Seaboard Corporation is **W. C. Day. J. S. Weaver** replaces Day as manager of Atlantic Seaboard transmission lines, and **W. H. Dean** replaces Weaver as superintendent of Line A. **R. F. Keeling** has been made district foreman at Huff Creek; **T. E. Cornell** has been transferred as foreman from Huff Creek to Union, and **Walter Lane** is the new foreman at Huff Creek.

R. E. Nelson, Jr.

R. E. Nelson, Jr., of Standard Oil Company (Indiana) on February 1, 1953, will join the Petroleum Administration for Defense in Washington, D. C., as director of the supply and transportation division. He will be granted a leave from his duties as Standard's general manager of crude oil supply and products pipe lines.

At PAD Nelson will succeed **C. E. Spahr,** vice president of the Standard Oil Company (Ohio).

Nelson was employed by the Dixie Oil Company in 1929 as a geological scout in West Texas. Later he joined Stanolind Oil and Gas Company of Tulsa, Oklahoma, where he served as district landman, assistant division landman, unitization superintendent, executive assistant to the director of producing and manufacturing, and division manager.

As division manager for Stanolind at Houston, Texas, he had charge of exploration, drilling, and producing activities of that company in the Texas and Louisiana Gulf Coast.

He was assistant to the president of Service Pipe Line Company at Tulsa when he was appointed general manager of crude oil supply and product pipe lines for Standard Oil Company (Indiana) at Chicago in 1950.

Nelson also is president of the Wyco Pipe Line Company.

He majored in geology at the University of Missouri and is an alumnus of Harvard University Graduate School of Business Administration.

▸ **P. W. Riggins,** recently division marketing manager of Continental Oil Company with headquarters at Fort Worth, Texas, has been appointed general sales manager of the Texas Gas Corporation, Houston, and its subsidiaries. Riggins has had considerable experience in the sale of refinery products, having spent more than 21 years in the sales department of Continental Oil Company. Prior to his being promoted to division marketing manager at Fort Worth, he handled jobbing and export sales at Continental's general office in Ponca City, Oklahoma. Texas Gas Corporation is a small but rapidly expanding organization handling approximately 250,000,000 cu ft of gas a day, purchasing, processing, and marketing through approximately 400 miles of pipe lines on the Texas Gulf Coast, operating three large plants including the refining of 5000 to 6000 bbl of condensate a day, producing approximately 6000 bbl daily of various refined products and transmitting through its products pipe line to deep water terminal at Port Neches. The company is planning on placing a large petrochemical plant in operation within the near future.

▸ **Van H. Wilkinson,** head of Wilkinson Products Company, Pasadena, California, was a recent business visitor in the midwest and southwest areas. As is quite well known, his firm manufactures a pipe line locator, and you would think that its president would be familar with all the uses to which it possibly could be put. But Wilkinson confessed that he learned of a new use on this trip. Officials of Geo. S. Kausler, Ltd., underwriters of New Orleans, told him of their experience in finding with one of his locators a $16,000 cargo of pipe that had been lost off a barge in the Gulf of Mexico near Corpus Christi, Texas. The pipe was in 34 ft of salt water but seemingly the salt water had no bearing on the effectiveness of the locating equipment.

▸ **Charles E. Dougherty,** Service Pipe Line Company, district gager in the company's West Texas division, has been promoted to division gager with headquarters at Williston, North Dakota, C. M. Scott, Tulsa, general manager, announces.

A native of Oklahoma, Dougherty joined Service Pipe Line in 1940 in Tulsa. In North Dakota he will supervise the gaging of oil received for shipment through the gathering system to a railroad loading rack at Tioga.

▸ **J. B. Thompson** and **J. K. Alfred** have been assigned to new administrative positions with Shell Pipe Line Company, Houston, Texas. Both now occupy positions of "assistant to the vice president." Thompson is assisting **Vice President D. F. Sears,** aiding in coordination of operational activities. Alfred is assisting **Vice President D. H. Lewis** on engineering and project development.

▸ **Robert G. Bushnell** has been elected vice president and **Arthur J. Helmbrecht** appointed assistant to the president of Buckeye Pine Line Company.

▸ **T. McGregor,** area maintenance supervisor at Springfield, Missouri, for Shell Pipe Line Corporation, has been promoted to district superintendent. **H. D. Burton,** relief dispatcher at Colorado City, Texas, has been made district gager in that area. **J. L. Howell** and **M. M. Maxwell,** field gagers, have been transferred from Eunice to Hobbs, New Mexico.

▸ **Chester Greenway,** formerly crew foreman at Garden City, Kansas, for Northern Natural Gas Company, has been made district foreman for the recently created Guymon, Oklahoma, pipe line district. The new district is under the Hugoton, Kansas, division. Transfer of the following personnel to the Guymon district has been announced: **Henry Staples,** Garden City utility man, and the following Hugoton employees; **Jim Foster,** crew foreman; **Wayne Brown,** district clerk; **Tom Johnson,** truck driver; **Dean Flummerfelt,** welder "A," and **Ned Carpenter,** maintenance man. New employees include **Lawrence Hoffman,** maintenance man; **Charles Hayes,** maintenance man; **Joe Miller,** maintenance man, and **Charles Claycomb,** field clerk. The above men will be under the supervision of **C. L. Anglin,** superintendent of the Hugoton division.

Working under **C. W. Ikard,** superintendent of gathering lines in the Hugoton division, will be three well operators transferred from Hugoton, **Leniel Goff, Forest Rowden,** and **Lois Cook.**

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PIPE LINE PROJECTS

FPC Dismisses Texas Eastern's Application

An application by Texas Eastern Transmission Corporation, of Shreveport, Louisiana, for a temporary certificate authorizing the delivery and sale of natural gas to Algonquin Gas Transmission Company, of Boston, Massachusetts, has been dismissed by the FPC for lack of jurisdiction.

The FPC, pointing out that it had dismissed Algonquin's application for a temporary certificate for its virtually completed pipe line system in New England, said that there was now no basis for Texas Eastern's application.

Algonquin and Texas Eastern filed their applications for temporary certificates after the Supreme Court refused to review a lower court decision setting aside a February, 1951, order of the commission granting certificates to the two companies. Hearings are now in progress to determine whether Algonquin or Northeastern Gas Transmission Company, of Springfield, Massachusetts, should be authorized to serve certain market areas in New England. In dismissing Algonquin's application for a temporary certificate, the FPC stated that it "does not come within the purview of the authority of the commission to grant."

United Gas Denied Offshore Application

A Federal Power Commission Presiding Examiner has filed a decision, subject to review by the commission, denying without prejudice an application by United Gas Pipe Line Company, of Shreveport, Louisiana, to construct about 31 miles of natural gas transmission line extending from an off-shore field in the Gulf of Mexico to a connection with another pipe line now under construction by the company in Terrebonne Parish, Louisiana.

The decision, filed by Examiner Glen R. Law, said that the natural gas reserves available to the company in the Ship Shoal area off Terrebonne Parish either presently or by the drilling of an additional well are not sufficient to justify the construction of the project. United had entered into a gas purchase contract with Phillips Petroleum Company, Kerr-McGee Oil Industries, Inc., and Stanolind Oil and Gas Company.

Examiner Law pointed out that the proposed construction would cost $4,458,000 or more than 7.6 cents per 1000 cu ft of gas in addition to purchase price of about 9 cents per 1000 cu ft, without allowance for the cost of operation of the proposed facilities.

Law said that considering present gas prices in East Texas and Louisiana, both in the field and for sale for industrial and other uses locally, "we cannot find ourselves justified in authorizing the construction of the proposed facilities upon the basis of the showing of reserves made up to this time."

The Examiner added that there is no contractural or geological evidence that United will hereafter obtain from other sources near the proposed line sufficient additional natural gas on either a long or short term basis to justify construction of the facilities and the inclusion of their cost in the company's rate base.

United has estimated recoverable reserves in the Ship Shoal area at about 300 billion cubic feet; however, it had proved reserves of only a little over 8 billion cubic feet in the 8500-ft sand, and had proved no reserves in the 14,000-ft sand, where it had expected to establish the existence of more than 292 billion cubic feet upon completion of a well. Examiner Law, however, assigning the same acreage for the 14,000-ft sand as allowed in the 8500-ft sand—or 640 acres instead of the 3750 acres estimated by the company—computed the reserves at that level at slightly under 50 billion cubic feet, for a total from both levels of 58 billion cubic feet.

The examiner's decision denies the company's application without prejudice to its right to file a further application if and when it has available the reserves to make construction and operation of the project "economically feasible in the public interest."

Kansas-Nebraska Granted Right to Change Plans

Federal Power Commission Presiding Examiner Francis L. Hall has filed a decision, subject to review by the commission, authorizing several minor changes by Kansas-Nebraska Natural Gas Company, Inc., of Phillipsburg, Kansas, in natural gas pipe line facilities previously authorized by the FPC.

The decision permits the company (1) to construct 3 miles of 2⅜-in. pipe in lieu of 8 miles of the same size pipe in Hall County, Nebraska, as authorized in a 1946 order of the FPC; (2) to install four 500 hp units instead of one 2000 hp unit at its new Holcomb, Kansas, compressor station, authorized by the FPC in February of 1951, and (3) to eliminate authorization in a February, 1951, order to serve Stanton, Nebraska, which would now be served by a different route.

The examiner's decision is subject to review by the commission either upon appeal by parties to the proceeding within 20 days or upon the FPC's own motion within 10 days thereafter. If no review is initiated, the decision will become effective after 30 days.

Colorado Interstate Order Is Amended

A Federal Power Commission order, issued last February, authorizing Colorado Interstate Gas Company, of Colorado Springs, Colorado, to increase its pipe line system capacity has been amended to require the company to file by October 15, 1953, emergency service rules providing for the "equitable distribution" of its gas unless additional capacity has been authorized and installed by that time to meet estimated firm requirements for the 1953-54 winter peak day.

The amendment replaces a condition in the February order directing Colorado not to attach any new customers or to render any additional services to its existing customers beyond that shown for certain periods set forth in exhibits presented at the hearing on the application.

The substitution of the new condition was suggested by Colorado at a rehearing held October 27. Colorado and one of its customer companies, Public Service Company of Colorado, of Denver, Colorado, had requested the rehearing because they contended that the original condition adversely affected certain priorities contained in rate schedules and service agreements on file with the commission.

Approval Given for Short Gas Pipe Line

New York State Natural Gas Corporation, of New York City, has received final authorization from the Federal Power Commission for the construction and operation of an 18-mile natural gas pipe line in Clinton and Cameron counties, Pennsylvania.

The 16-in. line will extend southwest from a connection with an existing line in Clinton County, Pennsylvania, to a point near the recently discovered Driftwood gas field in Cameron County, Pennsylvania. The company also was authorized to build 970 ft of 20-in. pipe in Tioga County, Pennsylvania, connecting its Sabinsville compressor station with existing transmission lines.

The commission at the same time permitted New York State Natural to withdraw, without prejudice, a portion of this same application, in which the company proposed to construct 75 miles of 20-in. line extending from the southern end of the Driftwood line to a connection with New York State Natural's system in Armstrong County, Pennsylvania. The company had planned to build this portion of the project in 1953, and requested permission to withdraw the part of the application relating to these facilities without prejudice to refiling.

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FPC Affirms Dismissal Of Algonquin Application

The Federal Power Commission has affirmed its order of October 31 dismissing an application by Algonquin Gas Transmission Company, of Boston, Massachusetts, for a temporary certificate authorizing it to continue construction and begin operation of its pipe line system, now virtually completed in New England.

The FPC said it again had found that Algonquin's application "does not come within the purview of the authority of this commission to grant."

After the October 31 dismissal of the application, Algonquin asked the FPC to reconsider its action and requested oral argument before the commission.

Hearing On Canadian Gas Import to Reconvene

The Federal Power Commission will resume hearings February 16 in Washington, D. C., on several proposals for the importation of natural gas from Canada to serve market areas in the Pacific Northwest and the Midwest. The hearings were recessed last July 7, subject to further order of the Commission.

Proceedings involve applications by Northwest Natural Gas Company, of New York City; Pacific Northwest Pipeline Corporation, of Houston, Texas; Westcoast Transmission Company, Inc., of Wilmington, Delaware; Glacier Gas Company, of Butte, Montana; Trans-Northwest Gas, Inc., of Spokane, Washington, all proposing to serve markets in the Pacific Northwest; and Northern Natural Gas Company, of Omaha, Nebraska, which plans to import gas from Canada into the Midwest.

The commission at the same time denied a motion made by its staff counsel last July 1 to deny all applications on the grounds that none of the companies had presented evidence disclosing a firm supply of natural gas despite an opportunity to do so. Counsel for an intervener, Trans-Canada Pipe Lines, Ltd., joined in the staff motion and also filed separate motions seeking dismissal of each of the applications. These motions also were denied.

FPC's order also grants permission to Pacific Northwest Pipeline Corporation for the filing of a second substitute proposal for constructing a pipe line system to serve the Pacific Northwest. The substitute proposal, submitted by the company on August 27, calls for construction of a system extending from the San Juan Basin in New Mexico and Colorado to a terminus near Bellingham, Washington. The company previously proposed to construct a pipe line system, mainly in Washington, to serve markets in the Pacific Northwest with natural gas imported from Canada, while at the same time exporting an equal amount of United States gas back across the border near River Rouge, Michigan, for consumption in Canada. Prior to that, and in its original application, Pacific Northwest proposed to build a pipe line system that would have linked the Texas gas reserve areas with

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Projects

gas fields in Alberta, to serve the Pacific Northwest states.

In ordering the hearings to reconvene, the commission pointed out that Westcoast Transmission Company, Inc., had recently filed data showing that its corporate parent and proposed supplier, Westcoast Transmission Company, Ltd., has received authority under the Pipelines Act of Canada to construct a pipe line for the transportation of gas to the U. S.-Canadian border for exportation.

The FPC directed each of the companies to submit by January 16 the information and data required by the August, 1952, amendment to the commission's rules relating to the form and filing of applications for certificates.

The commission's order denied a request by Glacier Gas Company that its application be severed from the other proceedings because it was not able to go forward with evidence in accordance with the procedural order.

Hearing Date Set for Ohio Fuel Requests

A Federal Power Commission hearing has been scheduled to start January 6 in Washington, D. C., on two applications by the Ohio Fuel Gas Company, of Columbus, Ohio, for authority to construct pipe line facilities in connection with its underground natural gas storage operations in Ohio.

In one of the applications (Docket G-1985), Ohio Fuel is proposing to expand its underground storage facilities by converting six producing pools to storage service in north central Ohio. Total estimated cost of this project is $4,880,000.

The other application (Docket G-2013), which involves facilities estimated to cost $1,675,000, requests authority for the construction of pipe line facilities to increase the capacity of the company's system to transport additional natural gas to underground storage and market areas.

In consolidating the two cases for hearing, the FPC pointed out that both involve common questions relating to the operation and expansion of Ohio Fuel's proposed Holmes (County) storage area.

Presiding Examiner Grants Kansas-Nebraska Request

A Federal Power Commission presiding examiner has filed a decision, subject to review by the commission, authorizing Kansas-Nebraska Natural Gas Company, Inc., of Phillipsburg, Kansas, to abandon a 13-mile pipe line extending from the Minden area to Kearney in Nebraska, and to construct a new 10-mile line to serve 21 rural customers now served off the Minden-Kearney line.

The 6⅝-in. Kearney-Minden line was built in 1930 to serve Kearney, but that city is now served by other facilities certified by the FPC. The only use now being made of the line is service to the rural customers, who will be served by the smaller 2-in., 10-mile line.

With the PIPE LINE CONTRACTORS

Associated Pipe Line Contractors, Inc., 3272 Westheimer Road, Houston, Texas, is nearing the halfway mark with its job for The Texas Pipe Line Company, which consists of 106 miles of 10-in. takeup between Erath station, Louisiana, and the Sabine River. The pipe is being reconditioned. The field office is at Lake Arthur. Jim Andrews is superintendent and J. B. Robbins office manager. The reconditioning yard is at Sulphur, Louisiana, with H. A. DeRouen in charge of the rack and Ralph Herwig office manager.

This contractor began work early in December on 17 miles of 8 and 12-in. for the Interstate Oil Pipe Line Company near Golden Meadow, Louisiana. William Briley is spreadman and R. N. Cain is in charge of the office.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, is nearing completion of 75 miles of 12-in. for Continental Pipe Line Company from Wichita Falls, Texas, to Duncan, Oklahoma. The field office is at Duncan. M. L. Boyd is superintendent and Chuck Siewert office manager.

In Kansas and Nebraska about 100 miles of 26-in. loops are being laid for the Northern Natural Gas Company. The field office is at Beatrice, Nebraska, with A. A. Carrigan superintendent and Dave Wagner office manager.

Between Merino, Colorada, and Gurley, Nebraska, 112 miles of 4-in. through 12-in. pipe is being laid for the Toronto Pipe Line Company. Field headquarters are at Sterling, Colorado. Oscar Phillips is superintendent and Jerry Short office manager.

Engineers Limited Pipeline Company, 225 Bush Street, San Francisco, California, has contracted to lay 150 miles of 8-in. pipe for Pioneer Pipe Line Company between Rawlings and Evanston, Wyoming, and has two spreads in the field. One is working out of Green River with Lynne Vassar in charge and Harvey Montague the office manager. The other has its headquarters at Rawlings. C. P. Hamilton is superintendent and H. W. Culver office manager.

The firm has contracted to lay 84 miles of 34-in. pipe for Pacific Gas and Electric Company, being loops between Topock, Arizona, and Bakersfield, California. The field office is at Barstow, California.

Anderson Brothers Corporation, 6300 Navigation Boulevard, Houston, Texas, had completed 177 miles (December 11) of the 267 miles of 24-in. being laid for Rancho Pipe Line Company between McCamey and Austin, Texas. The field office is now at Fredericksburg. Aldress Kilgore is superintendent, Russell McDowell office manager, and N. H. Zarafonetis paymaster.

Between Midland station and Goldsmith station, 37 miles of 10¾-in. pipe is being laid for the Gulf Refining Company. Three miles have been completed. Bob McGee is superintendent and Dick Bond office manager.

Also for Gulf, 21.2 miles of 10¾-in. pipe is being laid from Wortham station to Corsicana, Texas, the field office being at the latter point. Fourteen miles have been completed. Bob McGee is superintendent, Bill Houseman spread foreman, and Al Fiege office manager.

At the East Houston tank farm of Texas Pipe Line Company 12 miles of 6, 8, and 10-in. pipe is being taken up. Glenn Allman is general superintendent, Ray Bendure superintendent, Elmer Smith rack foreman, and Jack Gibbs take-up foreman.

O. R. Burden Construction Corporation, 6702 East 21st Street, Tulsa, Oklahoma, has started on the Standard Oil Company of Indiana job and has three spreads at work. The project consists of 186 miles of 12-in. pipe between Unionville, Missouri, and Dubuque, Iowa. Spread No. 1 has its headquarters at Ottumwa, Iowa, with Floyd Lewis superintendent and Ray Stewart office manager. Spread No. 2 has its field office at Sigourney, Iowa, where Fred Peters is superintendent and J. B. Thomas office manager. Spread No. 3 is working out of Anamosa, Iowa, where Al Perry is superintendent and Bill Robinson office manager.

Three spreads are working on the 600 miles of take-up for Sinclair Pipe Line Company between Drumright, Oklahoma, and Humboldt, Kansas. Paul Thibodeaux is in charge at Wynona, Oklahoma, with Guy Carder office manager. At Hallett, Oklahoma, R. C. Wilkerson is superintendent and Doyle Williams office manager. The third spread is at Independence, Kansas, where Ted Price is superintendent and John Freeman office manager.

Sparling-Davis Company, Ltd., 7310 99th Street, Edmonton, Alberta, Canada, is working on a 24-in. river crossing near Kamloops, British Columbia, for Trans Mountain Oil Pipe Line Company, subcontracted from Mannix, Ltd. D. R. Hibbs is dredge superintendent and Cliff Poole superintendent.

Engineering-Construction Company, 402 North Cheyenne, Tulsa, Oklahoma, is engaged in laying 75 miles of 4, 6, and 8-in. pipe for the Kansas-Nebraska Natural Gas Company near Chappell, Nebraska. Earl Hackleman is spreadman and G. Hoge office manager. This job will be completed about the middle of January.

Mannix, Ltd., 332 Seventh Avenue West, Calgary, Alberta, Canada, has 224 miles of 24-in. line for Trans-Mountain Oil Pipe Line Company extending from Blue River to Coquihalla Pass, British Columbia. The field office is at 412 Victoria Street, Kamloops, British Columbia. C. P. Baker is project manager.

Sheehan Pipe Line Construction Company, 529 National Bank of Tulsa Building, Tulsa, Oklahoma, has completed about half of the 84 miles of 12-in. pipe line being laid for Standard Oil Company of Indiana between Polo and Unionville, Missouri. One spread has its headquarters at Milam, Missouri, where C. M. Brown is superintendent, "Peanut" Kinkaid spreadman, and R. L. McElroy office manager. A second spread is working from Breckenridge, Missouri, where Jim Brown is superintendent and Gerald Burgoon office manager.

An 8-in. crossing of the Kankakee River has been completed for Phillips Pipe Line Company.

H. C. Price Co., Pipeline Division, Box 1111, Bartlesville, Oklahoma, at the present time has three spreads working on 363 miles of 26-in. pipe line for the Texas Gas Transmission Corporation, from the east bank of the Mississippi River near Greenville, Mississippi, to Jeffersontown Station, a few miles east of Louisville, Kentucky.

Spread No. 1 has its headquarters at Princeton, Kentucky. This spread was assigned loops totaling 45 miles. Pipe was laid out as of December 10. G. A. Reutzel is superintendent and W .E. Yount office manager.

Spread No. 2 is making its headquarters at St. Mathews, Kentucky. This spread has loops totaling 98 miles, with 18 miles remaining to be laid as of December 10. R. L. Ezell is superintendent and W .R. Crego office manager.

Spread No. 3 has its headquarters at Ripley, Tennessee. Assigned to loops totaling 59 miles, this spread had 12 miles remaining to be completed on December 10. C. E. Shivel is superintendent and W. R. Crego office manager.

An additional 135 miles of loops in Mississippi were completed by Spread No. 4 under Superintendent C. R. Ice.

A contract covering construction of approximately 833.4 miles of loop and new lines for Southern Natural Gas Company in Louisiana, Mississippi, Alabama, Georgia, and South Carolina, is shared by H. C. Price Co. and Houston Contracting Company. Spread No. 4, with headquarters at Oxford, Alabama, is at work on this job, with 16.6 miles completed to December 10. C. R. Ice is superintendent and G. A. Harvey office manager.

Vaughn and Taylor Construction Company, P. O. Box 1351, Wichita Falls, Texas, is constructing a gathering system in the vicinity of Odessa, Texas, for Phillips Petroleum Company, consisting of 268 miles of 2-in. through 30-in. pipe. D. D. Vaughn is superintendent and Clark Sayles office manager.

Between Arden and Eldorado, Texas, 40 miles of 16-in. pipe line is being laid for Pan-American Pipe Line Company. A field office has been established at San Angelo, with D. D. Vaughn superintendent and W. W. Teer office manager.

Contractors

Holder Construction Company, Snyder, Texas, began work December 15 on 29 miles of gasoline pipe line for The Texas Pipe Line Company in Scurry County, Texas. The line, 4½-in. in diam., will extend from The Texas Company's Fuller Ranch gasoline plant to the Basin Pipe Line Company's pump station at Colorado City.

Modern Welding Company, Owensboro, Kentucky, has been awarded a contract for the installation of a complete natural gas transmission line and distribution system for the city of Fort Valley, Georgia. Porter and Barry, Baton Rouge, Louisiana, are the consulting engineers for the project. Work is scheduled to begin in early 1953.

Other contracts for natural gas lines now under construction by Modern Welding Pipeline Division are Tullahoma Natural Gas Company, Tullahoma, Tennessee; City of Lawrenceburg, Tennessee; Owensboro-Ashland Oil Company additions, and Western Kentucky Gas Company additions.

H. L. Gentry Construction Company, 921 East Michigan Avenue, Jackson, Michigan, is laying 19 miles of 12-in. and 3½ miles of 16-in. pipe line for the Binghamton Gas Works in the vicinity of Binghamton and Van Etten, New York. Six miles of 8-in. is under construction between Barber and Linden, New Jersey, for the California Oil Company.

Missouri Valley Canadian, Ltd., 640 West Hastings Street, Vancouver, British Columbia, Canada, is guniting 5700 ft of 24-in. pipe, which will be used in a crossing of the Fraser River on the Trans Mountain Oil Pipe Line Company system. The field office is at New Westminister, British Columbia. Joe N. McMaken is general superintendent and Pierce R. Binford pipe superintendent.

Houston Contracting Company, 2707 Ferndale Place, Houston, Texas, has the following construction work under contract:

Approximately 190 miles of 24-in. crude oil line for Rancho Pipe Line Company from Pasadena, Texas, west to Cedar Valley, about 20 miles west of Austin. E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, field office manager. Headquarters are at Columbus, Texas. Expect to complete job in February, 1953.

Approximately 6½ miles of 16-in. natural gas line for Tennessee Gas Transmission Company near Grand Chenier, Louisiana. This is a marsh job with the spread making its headquarters on a quarter boat in the vicinity of Rollover Bayou. H. L. Leake is superintendent, S. B. Harrison assistant superintendent, and H. C. MacWhinnie, field office manager. Land headquarters are at Abbeville, Louisiana.

Approximately 34 miles of 6-in. butane line for The Texas Pipe Line Company from Sour Lake to Port Arthur, Texas. Job to start in January; personnel and headquarters to be announced later.

Approximately 525 miles of 24-in., 20-in., 16-in., and 14-in. natural gas lines for Southern Natural Gas Company in Georgia, Mississippi, and Louisiana. Work to start about March, 1953.

L. E. Farley, Inc., 2609 Sunset Boulevard, Houston, Texas, will lay 64 miles of 16-in. pipe for Interstate Oil Pipe Line Company between Morgan City and Baton Rouge, Louisiana, as soon as the pipe becomes available. The field office will be at Plaquemine with Doc Berton superintendent, Ernest Tyrney spreadman, and Fred Hudson office manager.

Panama-Williams Company, 1417 Melrose Building, Houston, Texas, has two spreads working on 86 miles of 26-in. pipe line for the West Texas Gulf Pipe Line Company between Livingston and Beaumont, Texas. The spread in charge of Gene Coulter has its headquarters at Livingston. Ernest Smith is office manager. The second spread is working out of Beaumont. Panama Shiflett is superintendent, Cooney Shiflett assistant superintendent, and Lloyd Evans office manager.

Between McCamey and Crane, Texas, 22 miles of 12-in. is being laid for the Texas-New Mexico Pipe Line Company. The field office is at McCamey. Lawrence Williams is superintendent.

For Pure Transportation Company, 13 miles of 8-in. is being laid in Andrews and Winkler counties, Texas.

Williams Brothers de Venezuela, S. A., Maracaibo, Venezuela, is laying 170 miles of 26-in. pipe line for the Creole Petroleum, from Ule station on east side of Lake Maracaibo to Amuay Bay. Marvin Jones, superintendent.

Brown and Root, Inc., 4100 Clinton Drive, Houston, Texas, are at work on 28 miles of 26-in. pipe line for the Pan-American Pipe Line Company, between Texas City and Genoa, Texas. The crew is under director of Jimmy Kincy.

J. L. Cox and Son, P. O. Box 386, Raytown, Missouri, are stringing 340 miles of 22-in. pipe between Salisbury, Missouri, and Schererville, Indiana, on the Sinclair Pipe Line Company system. Other jobs for Sinclair are the stringing of 400 miles of 8 and 12-in. from Shannondale station to Wood River station, Illinois, 600 miles of 8-in. through 14-in. pickup between Manuel station, Oklahoma, and Independence, Kansas.

Mary Construction Company, Cape Girardeau, Missouri, is laying approximately 180 miles of 8-in. pipe line for the Indiana Farm Bureau Cooperative Association, from Mt. Vernon to Jolietville, Indiana. Headquarters are at Princeton. Garland Mims is superintendent and Lewis Wiist office manager.

R. E. Pitts Contracting Company, Clarksville, Arkansas, has under construction approximately 100 miles of city and plant work for the MidSouth Gas Company, pipe ranging in diameter from 1 in. through 8 in. Ralph Pitts general superintendent and "Tex" Glover assistant.

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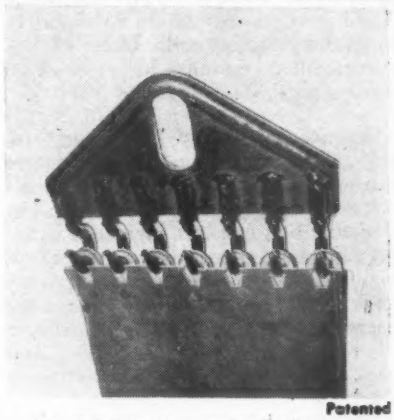

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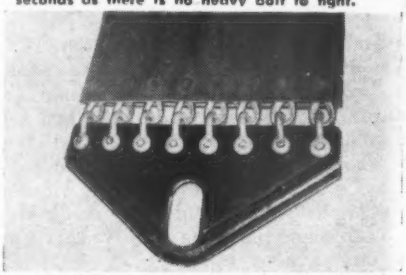

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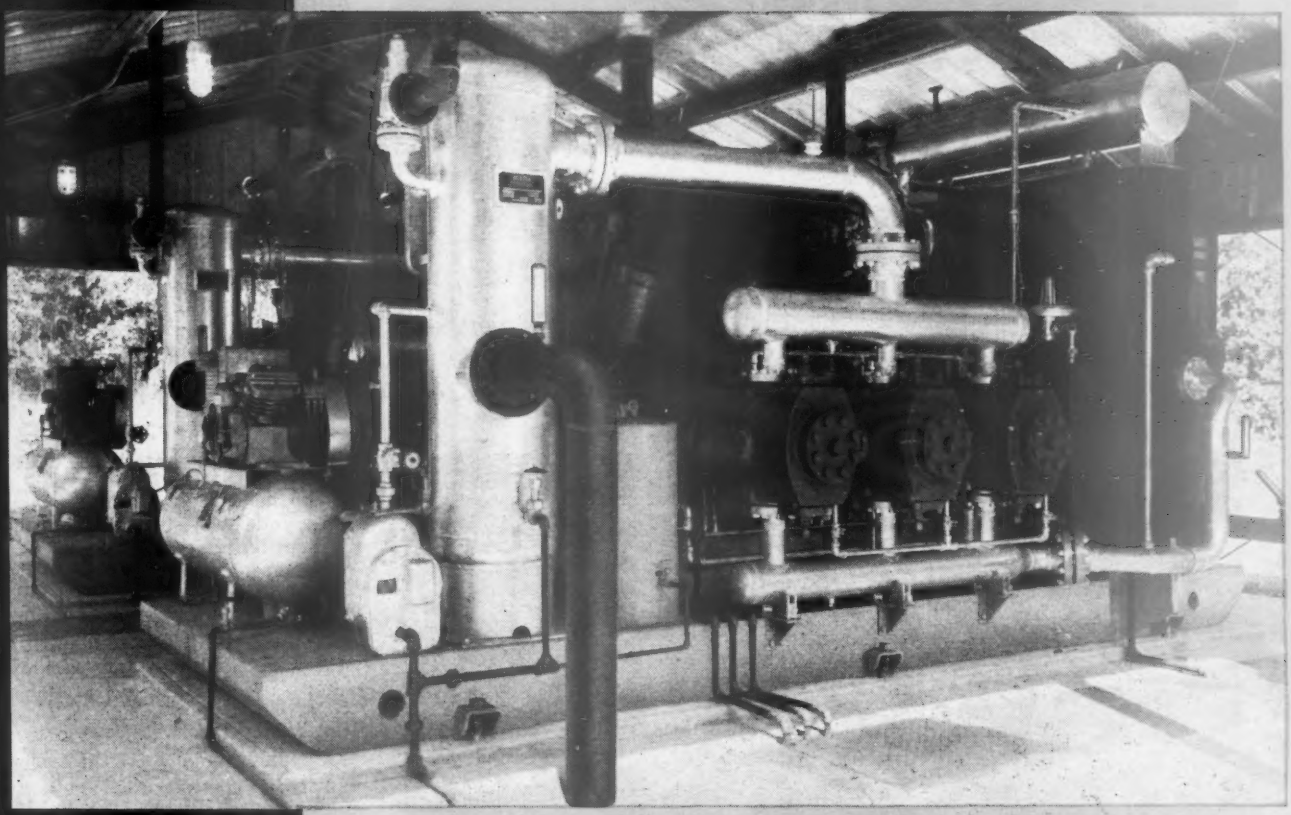

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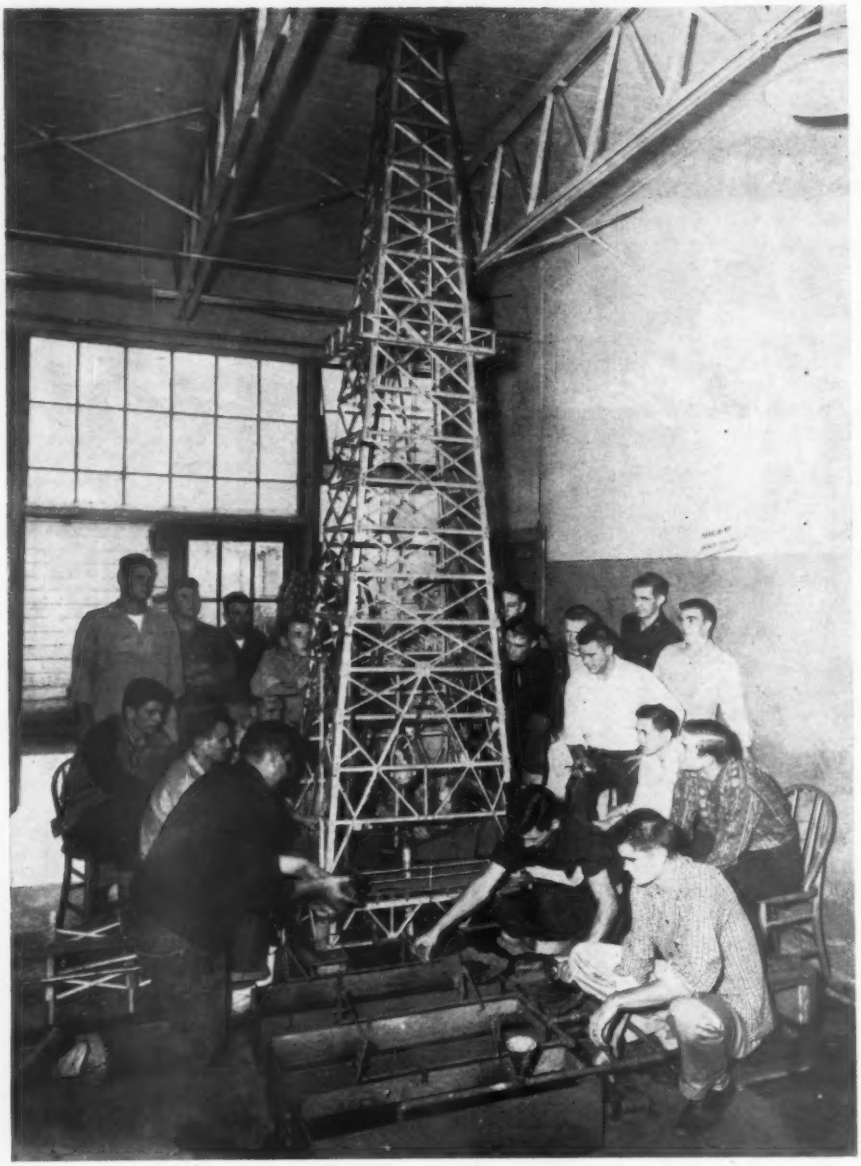

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Drilling Practice Course Aids Petroleum Industry

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W. R. MAYS

IN January, 1947, at Kilgore College the first drilling practice course ever offered was established under the joint sponsorship of the American Association of Oilwell Drilling Contractors, and The University of Texas, Extension Division.

The purpose of this course was to supply the drilling industry with better trained employees. Originally, the course was set-up for 12 calendar months and included both classroom work and actual drilling rig operations. Classroom instruction included mathematics, chemistry, drilling mud, and rig equipment.

In September, 1951, in order to better meet the needs of both the students and the industry, the course was changed to a two semester, nine months course. The actual drilling rig instruction was eliminated and the course now consists of classroom and laboratory instruction. The classroom instruction is divided into the following courses: Chemistry, physics, slide rule, metallurgy, petroleum geology, rig equipment, well logging and drilling mud. Laboratory work is in chemistry, physics, and drilling mud.

The basic sciences, chemistry and physics, are taught to better prepare the students for the more advanced courses to follow, such as metallurgy, well logging, and drilling fluid. Many of the students have not had these sciences in high school, so the courses are designed to bridge the gap. Every effort is made to correlate the courses with the actual drilling job.

Slide rule is taught as a two-hour course.

The metallurgy course is offered in the second semester. Most of the time is spent on ferrous metallurgy from the mine through the blast furnace to the steel mills and the making of special alloys. Again the emphasis is placed on the subject as applied to the drilling operations. Properties and uses of other metals used in drilling are discussed. Some time is spent on corrosion problems.

Petroleum geology is also offered in the second semester. This course covers the origin of petroleum, suitable traps, properties, and its accumulation. Typical fields are discussed that illustrate the type of trap, contour maps, cross sections, method of discovery, geology, and production history. Some time is spent on methods of discovery and recovery mechanisms.

Rig equipment covers all the rotary drilling equipment in detail, for example, the power plant, the hoist, rotary

The Author

W. R. Mays is an instructor in drilling practices at Kilgore College, Kilgore, Texas. A graduate of the Missouri Schools of Mines and Metallurgy, Mays worked for East Texas Refining Company for 10 years as tester, clerk, plant superintendent, chemist, and instrument repairman. He spent two years as analytical chemist for Associated Refineries in Duncan, Oklahoma, and then three years as a sales and service engineer on plastic services for Halliburton Oil Well Cementing Company, Kilgore. He has been an instructor at Kilgore College since 1948.

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This new branch is in addition to the five Hercules branches located at Los Angeles, Calif., Salem, Ill., Houston, Odessa and Kilgore, Texas, and is to provide additional facilities for the increased demand of Hercules products. In addition the following Hercules distributors in the mid-continent area maintain adequate stocks of power units and parts for sales and service:

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Students mixing mud at Kilgore, Texas, college.

table, drilling string, drill collars, mud system, control instruments, deviation recorders, cementing, testing, and auxiliary equipment. To keep this material up-to-date liberal use is made of the leading oil journals, manufacturers' publications, movies, and equipment on loan from manufacturers.

The well logging course covers the basic principles of all types of subsurface evaluation. Electric logging is studied, and the electrode systems and their principle uses. Actual log interpretation is not emphasized as this is an engineering study. Other subsurface methods studied are caliper logging, radioactive logs, temperature logs, and mud and cutting analysis.

The drilling mud course is taught the entire nine months and is the most comprehensive. The first semester is devoted to water clay muds and the second semester to special mud systems. The students mix muds (see photo), contaminate and treat them. The uses and properties of the muds are discussed in class, field handling, lost circulation, heaving shale, and other problems. All the testing methods are used. This course is also kept up-to-date by the use of the oil journals and articles from the leading mud companies.

All the courses are helped by the liberal use of moving pictures provided by the steel companies, oil companies, equipment manufacturers, and service companies. Several field trips are made each year to equipment manufacturing plants. Classroom aids, on loan from companies, are drilling bits, floating equipment, wall cleaners, centralizers, deviation recorders, and others.

Drilling Rig Model

The most effective classroom aid is the 1/10 scale model drilling rig shown on page E-2. It was made by students of the machine shop and is operated by the drilling practice class. It has actually drilled about 30 ft at its classroom location. It is complete in every detail and is used by these students in actual practice. The catheads and mud pump are the only parts not made in the school shop. These items were made by the manufacturers of this equipment.

Originally, most of the students were veterans who came back to school to better prepare themselves for jobs. Some of the students are sent by their companies to train them for better jobs—engineers, tool pushers, etc. At the present time, a few Korean veterans are enrolling, but most of the students are recent high school graduates. Geographically, the students have been from Texas, Louisiana, and California. Other states represented include West Virginia, Mississippi, Michigan, New York, Florida, Oklahoma, Illinois, New Mexico, Indiana, and Arkansas. There have been two students from Venezuela.

About 180 students have finished this course and there are 25 enrolled at the present time. Those finishing this course have been employed by drilling contractors, service companies, supply houses, and drilling fluid companies. For the past year the most popular job choice has been with well logging crews for mud and cuttings analysis. Several of the graduates are working as mud engineers for one of the large service companies. A few have become drillers and tool pushers. Usually the students have a choice of jobs when they finish the course.

The overall purpose of the course is to turn out a better trained prospective employee. With the limited number of graduate engineers today there is an even more acute need for technically trained employees to carry part of the load of an industry that is rapidly becoming more technical. Drilling employees today must be better trained than ever before. With the type of training described here the student gets a general understanding of the industry and highly specialized training in equipment and drilling fluid. With a brief training period in company policy and a few job details the student should become a superior employee. * * *

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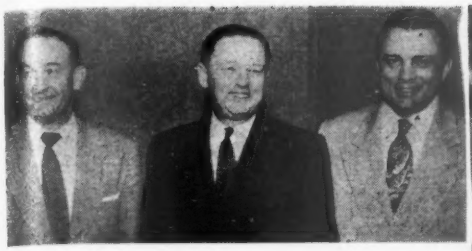

Los Angeles Nomads heard Major General D. H. Rudelson (above center) who spoke on Korea at the November meeting. With him are Bill Sargent (left) of Sargent Engineering, who presided, and Joe Schlarb of Chiksan Company, who introduced the General.

International guests at right are: Standing, Kenneth Smith, Trans-American Pipe Line, Iraq; Mario Cueto of Reed Roller Bit, Buenos Aires; Edmond M. Mong of Iraq Petroleum, Iraq; Ralph H. Connor of Transworld Management, formerly with IPC; Vincent W. Vandiver, foreign exploratory geologist with Seaboard. Seated, H. H. Mitchell of IPC from Basrah; C. H. Vincent of BMP (Shell); E. E. Higley of Ralph M. Parsons Company, back from China and going to South America; R. M. Long of IPC, from Iraq.

Independents Want Steel Controls Ended

Despite the pleas of a great majority of oil producers for decontrol of steel for the oil industry, the Petroleum Administration for Defense is standing firm on its belief that controls are necessary. Harris Bateman, head of PAD's material division, told the National Petroleum Council that PAD favors keeping controls on to make certain that all oil companies, both large and small, get a fair dent. Charlton H. Lyons, wrote J. Ed Warren recently that 424 members of IPAA showed they favor immediate decontrol and 162 opposed decontrol at this time. Lyons did not ask for immeamount of steel.

In a recent poll of the Independent Petroleum Association of America, more than two and one-half to one favored ending control immediately. IPAA presidiate decontrol, but requested that PAD "seek decontrol of oil country tubular goods as early as practical."

Warren, a former president of IPAA has indicated that he favors keeping on controls until shortages of steel have been eliminated. R. L. Foree, head of the production division, warned producers of continued shortages, and the steel industry itself has foreseen shortages of oil well steel.

F. W. Brigance, president of the American Association of Oilwell Drilling Contractors, has warned members of that organization that decontrol of oil country tubular goods "at this time" might bring hardships.

In a special bulletin, Brigance said the present inventory of tubular goods is the "lowest it has ever been," adding controls might be lifted satisfactorily by the end of the first quarter.

May World Output Down

World crude production in May, averaging 11,191,000 bbl daily, was only 90.4 per cent of the average rate in April, according to the Bureau of Mines. Principal contributor to the decrease was the United States, where daily average production in May, dropping as refinery strikes occurred, was 5,107,000 bbl compared to 6,429,000 in the previous month. During May, record daily average production rates occurred in Canada (180,000), Venezuela (1,844,000), Iraq (402,000), and Indonesia (182,000).

Imports of crude into western Europe averaged a record 1,370,000 bbl daily, an increase of 1.7 per cent over the April rate. A decline of 50,000 bbl daily in imports by the United Kingdom was offset by record daily movements of 442,000 and 180,000 into France and Italy respectively, as well as by a 47.8 per cent increase in daily average imports into the Netherlands during May.

Exports of crude from Venezuela in May averaged a record 1,534,000 bbl daily, compared to the previous rate of 1,511,000. Likewise a record daily average movement of 1,632,000 from the Middle East (exclusive of shipments to Bahrein) occurred during May, an increase of 3.4 per cent. Both Iraq and Kuwait exported at record daily average rates of 312,000 and 770,000 bbl.

Bahrein to Pay New Tax

The Bahrein Petroleum Company, Ltd., will have to pay a tax of 50 per cent on net income from the production and sale of Bahrein crude, retroactively to January 1, 1952. The new tax has been levied by the Bahrein ruler, who put it into effect December 15. Bahrein Petroleum is owned jointly by The Texas Company and Standard of California.

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News

PAD Allots Line Pipe For First Quarter 1953

The Petroleum Administration for Defense has allotted priorities for 235,353 tons of line pipe to pipe line and other projects for the first quarter of 1953. Fourteen large pipe lines will get 222,896 tons of the pipe, according to Interior Secretary Oscar L. Chapman.

PAD also announced that it does not think the time is ready for decontrolling oil country tubular goods. The steel industry has recommended such decontrol be put into effect by March 31.

One-hundred eighty-nine oil and gas operators have been granted individual allotments of 35,136 tons of conversion casing and tubing for the first quarter of 1953. A total of 8078 tons was allotted to 142 "A" operators—those who normally drill 40 or fewer wells in a 12-month period, and 27,058 tons were allotted to 47 "B" operators—those who normally drill more than 40 wells in a 12-month period.

California Oil Supply Dependent on Steel

Current shortages in California petroleum production can be overcome if enough oil country tubular goods to drill 3190 wells in the state are made available in 1953, an analysis by Oil Producers Agency of California shows.

The analysis, sent to Deputy Petroleum Administrator for Defense J. E. Warren by D. T. Staples, Oil Producers Agency president, calls upon the Petroleum Administration for Defense to consider the California petroleum situation an emergency and to take whatever steps are necessary to provide the materials to overcome it.

In order to meet estimated demands, including full military requirements which California production is at present unable to supply, 276,000 bbl of production per day will have to be developed in 1953, the analysis shows. This figure will offset the normal decline of producing fields and provide enough additional petroleum to bring total production to an average of 1,214,000 bbl daily, equal to the estimated 1953 average total daily demand, the agency declared.

Rising Imports Termed Threat to U.S. Economy

Oil imports should come into the United States "only in a manner and in such quantities that will not destroy the domestic oil industry," Russell B. Brown, Washington, D. C., general counsel of the Independent Petroleum Association of America, said in Albuquerque, New Mexico.

Speaking at the annual meeting of New Mexico Oil and Gas Association, Brown said increasing imports "present problems for solution in the near future that may prove far more serious than those that have confronted the industry for many years."

He recalled government efforts in 1929 to "close down the search for and development of oil in the United States" and to supply markets then supporting the domestic industry from foreign production. He said at that time imports had reached 10 per cent of total U. S. requirements, and exports amounted to about 15 per cent of requirements.

"That import position was improved through efforts of domestic producers until, in 1933, we were importing only 3.2 per cent of our total demand," he said, adding:

"Today we face accelerated imports that have climbed back to a rate of 12.5 per cent of total demand for the month of September 1952, with indication of further increases. Exports, except for oil to replace lost Iranian production, will be much lower percentagewise than at any previous time."

Brown declared rising imports "constitute a great threat to the domestic industry's ability to reach the proportions necessary to the nation's welfare."

NPC Storage Report Out

The National Petroleum Council has reported that the oil industry must have about 100 bbl of petroleum storage capacity to every 50 bbl of oil actually held in storage. Presented by L. S. Wescoat, president of Pure Oil Company, and chairman of the council's committee of petroleum storage capacity, the report was in response to a request made by PAD for up-to-date information on storage.

The study revealed that storage capacity of the oil industry had increased considerably in the last four years, particularly in the "clear" products group. Also in the "unavailable" inventories, such as those required to keep pipe lines filled and those in transit by tanker, barge, tank car, and truck had also grown.

Gasoline Price Down

Standard Oil Company of California has announced a reduction in the price of gasoline and other fuels in parts of Southern Idaho and Eastern Oregon. The price reduction ranges up to a half-cent per gallon for motor gasolines, diesel, and stove oils.

In making this announcement, Standard explained that increased volumes handled, and operating efficiencies in distribution have combined to make the lower prices possible. Standard reduced prices substantially in this area two years ago, on completion by a subsidiary of a pipe line from Salt Lake City, and at that time announced that further price reductions would be forthcoming in the future if operating economies permitted. Lower prices are also effective at bulk plants served by the terminals.

Discuss LPG Price Rise

Members of the Liquefied Petroleum Gas Industry Advisory Committee, at its first meeting with OPS officials, discussed requests for a higher ceiling price for liquefied petroleum gas sold from underground storage remote from producing plants.

Discussion centered around a proposal that gas sold from remote storage be granted an additional half-cent above the two-cent differential already provided under CPR 17 for gas sold from underground storage located adjacent to producing plants.

An over-all price increase because of increased costs in making, moving, and selling liquefied petroleum gas was also suggested by several members as a possible solution to their problems.

Crude Petroleum Stocks Dip Slightly

Stocks of domestic and foreign crude petroleum at the close of the week ended November 29 totaled 265,524,000 bbl, according to data reported to the Bureau of Mines, United States Department of the Interior. Compared with the total of 267,068,000 bbl for the preceding week, this represents a decrease of 1,544,000 bbl comprising a decrease of 1,089,000 bbl in stocks of domestic crude and a decrease of 455,000 bbl in stocks of foreign crude.

Stocks of crude petroleum November 1, 22, and 29, 1952.
(thousands of barrels)

	November 1	November 22	November 29	Change from November 22	Change from November 1
Pennsylvania Grade	2,198	2,268	2,219	—49	21
Other Appalachian	1,984	1,838	1,844	6	—140
Lima–Michigan	643	602	588	—14	—55
Illinois–Indiana	11,577	11,440	11,483	43	—94
Arkansas	2,918	3,270	3,264	—6	346
Kansas	9,979	10,157	10,290	133	311
Louisiana	16,162	15,735	16,303	568	141
North	2,567	2,413	2,382	—31	—185
Gulf	13,595	13,322	13,921	599	326
Mississippi	2,993	3,072	3,046	—26	53
New Mexico	7,578	7,140	7,237	97	—341
Oklahoma	27,887	26,688	26,675	—13	—1,212
Texas:	129,891	131,820	129,827	—1,993	—64
East Texas Proper	12,393	12,065	11,721	—344	—672
West Texas	59,040	60,574	59,716	—858	676
Gulf Texas	26,186	26,430	25,926	—504	—260
Other Texas	32,272	32,751	32,464	—287	192
Panhandle	3,103	3,213	3,172	—41	69
North	7,308	7,547	6,843	—704	—465
South	5,882	5,868	6,245	377	363
Rest of State	15,979	16,123	16,204	81	225
Wyoming	12,563	12,085	12,292	207	—271
Other Rocky Mountain	2,557	2,534	2,376	—158	—181
California	31,594	30,527	30,643	116	—951
Foreign	8,011	7,892	7,437	—455	—574
Total crude stocks in U. S.	268,535	267,068	265,524	—1,544	—3,011
Total located in PAW District 1	17,813	17,352	17,057	—295	—756
Total located in PAW District 2	88,541	86,642	85,950	—692	—2,591

Prepared under the supervision of H. J. Barton, Petroleum and Natural Gas Economics Coordinator, Petroleum and Natural Gas Branch.

International Guests of Los Angeles Nomads recently were: W. J. Larson, Dunlap and Graham, Lima, Peru; H. F. Giles, Socony-Vacuum, Sumatra; G. E. Boyd, Baker Transworld, Edmonton, Canada; C. D. Hendershot of NPPM (Cal-Tex Pac), Sumatra. Seated, T. Vanderwert, Aramco, Dhahran, Saudi Arabia; Leslie Noell, Santa Fe Drilling, Lebanon; Fernando Nieri, Empresa Petrolera Fiscal, Zorritos, Peru; W. N. Thompson, Texas Petroleum, and Ray E. McNeil, Texaco, Colombia.

Oil Industry Pays Most Taxes, Report States

Staff members of the University of Texas Bureau of Business has reported that the State Legislature centers on gas, oil, and sulfur taxes and leaves other valuable natural resources of Texas without special taxes. Petroleum and its products, including gasoline, paid 65.6 per cent of all state taxes in Texas during 1950, the report stated. Natural gas transmission companies and utilities usually can shift the tax onto the consumer, but until the Federal Power Commission allows rate increases the gas companies must absorb the tax.

Chapman Is Honored With Testimonial Dinner

A testimonial dinner was given Interior Secretary Oscar L. Chapman recently by members of the National Petroleum Council, in appreciation of the support they have received from him in their attempt to keep the council a free body.

The citation by the group recalled that in 1946 Chapman first insisted that the council remain an independent body with an industrial chairman. He defended that stand five years later when the Department of Justice demanded that the council be placed under a governmental head. Carrying the fight to President Truman, Chapman convinced him that only by keeping it an all-industry body could the Government obtain full cooperation of the oil and gas industries.

In the course of the evening, Chapman presented the Conservation Service Award of the Department of the Interior to Walter S. Hallanan, president of Plymouth Oil Company, for his "invaluable work" for more than six years as chairman of the NPC. Chapman's letter of presentation read in part:

"In recognition of your wholehearted enthusiastic interest and the invaluable work you have done for over six years as chairman of the National Petroleum Council, it is a real pleasure to present to you the Conservation Service Award of the Department of the Interior."

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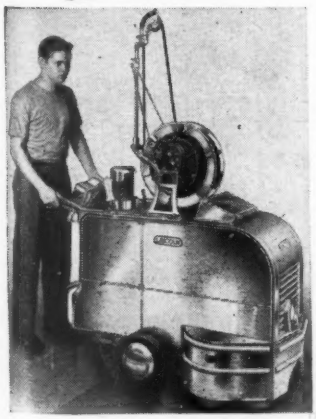

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News

Imports of Foreign Crude Stay at 1,000,000 Bbl Mark

Imports of foreign crude oil stayed over the 1,000,000 bbl per week mark December 6, after having gone over that figure October 18, the American Petroleum Institute reported.

Total imports were 1,049,400 bbl, slightly up from the 1,031,800 bbl for the week ended November 29.

Week ended	Crude oil	Residual oil	Others	Total
November 8.	513,000	411,800	3,600	928,400
November 15	751,600	335,300	12,800	1,099,700
November 22	655,300	342,800	23,200	1,021,300
November 29	645,100	358,700	28,000	1,031,800
December 6..	477,400	546,600	25,400	1,049 400

Exports for the weeks ending October 17, 24, 31, and November 7, and 14 are set out below in thousands of barrels a day by PAD:

	Avgas	Motor gasoline	Kerosine	Distillate	Residual	Total
October 17....	29.1	48.0	12.0	79.7	44.3	213.1
October 24....	30.5	22.1	8.5	145.0	69.5	275.6
October 31....	35.2	35.4	4.0	81.7	18.5	174.8
November 7....	41.1	72.7	14.2	106.0	36.1	270.1
November 14..	37.6	27.6	5.0	141.9	27.2	239.3

Dutch Refuse AIOC Files

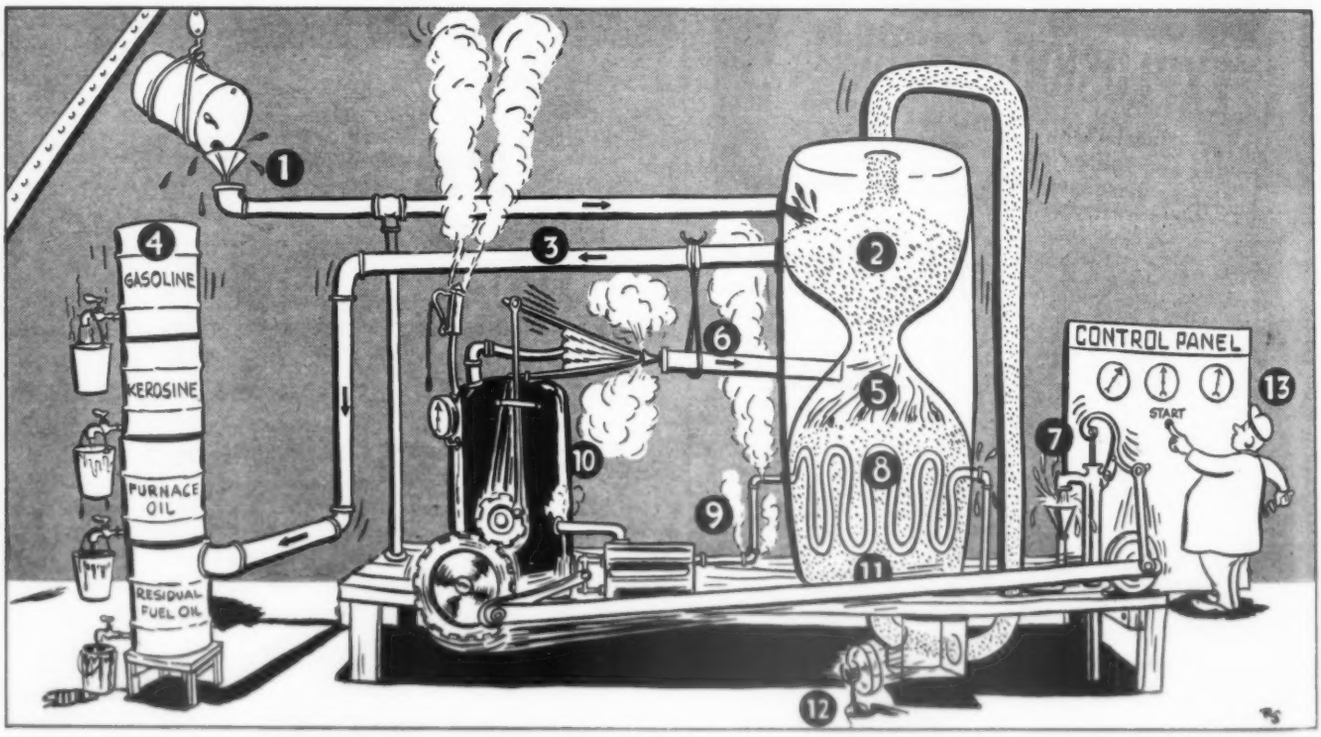
The Netherlands government has announced to the United States that it will not submit documents of oil companies established in that country to be used in the case against international oil cartels. The U. S. had demanded the files on the basis of American share holding in the companies based in the Netherlands. The Dutch government announced it was "concerned" about the way companies established in the Netherlands had been "indirectly" involved in the anti-trust action now going on in the U. S.

The communique from the Netherlands government did not identify the companies referred to but a foreign affairs office spokesman said it referred to subsidiaries of Standard Oil (New Jersey) and Caltex Petroleum.

The Anglo-Iranian Oil Company has been removed from the U. S. Government's investigation of the so-called world-wide oil cartel. The British-dominated company was declared as having "sovereign immunity." A subpoena in which the U. S. asked the company to produce various documents was automatically squashed by the ruling.

Stork Club in New York City was scene of recent Nomad party. Guests at the gathering were: R. W. Parker, California-Texas, Australia; Granville Parker, Texaco, Bogota, Colombia; E. C. Hendrix, International General Electric, Caracas, Venezuela; Dennis Slatford, Trinidad Oilfield Service, Trinidad, BWI; George Lockett, Mene Grande, Maracaibo; Carlos Bejarano, Motores, S. A., Bogota, and J. Feger, SNPA, Paris.

LAYMAN'S FLOW DIAGRAM OF HOUDRIFLOW UNIT



This is our artist's impression of how Toledo's big HCC unit operates. Oil to be cracked (1) enters reactor where (2) it comes in contact with hot catalyst and cracking takes place. (3) Cracked oil leaves reactor, goes to (4) fractionating tower. Catalyst flows downward into kiln (5) where air (6) is introduced to burn off carbon deposited on catalyst in cracking reaction. This is called regeneration. Water (7) is pumped through coils (8) around kiln to control heat of regeneration. The water becomes steam (9) which powers air blower (10) which supplies air for regeneration, which creates more heat to make more steam to supply more air, etc., etc. Meantime, regenerated catalyst leaves bottom of kiln (11) is picked up by air lift (12) and returned to top of reactor. (Actually, air which lifts catalyst is part of the air which has been used to burn carbon from the catalyst.) As you can see (13) the whole operation is controlled automatically by operator at a control panel.

From Our Sun, Sun Oil Company magazine.

MEMBERS SEEN AT API ANNUAL MEETING IN CHICAGO . . . . . .

Max E. Crawford
International Petroleum
Peru

S. C. Canary
Zephyr Petroleum

W. Camden
Camden Drilling

Henry E. Koopman
Phillips Petroleum

Charles A. Fisher
Chrysler Corporation

H. M. Cosgrove
Purchasing Agents
Association

John Babb
National Supply

C. B. Hussey
Gulf Oil

M. I. Taylor
Gulf Oil

M. E. Merkt, Jr.
Gulf Oil

J. B. Steele
Kewanee Oil

Men of the Petroleum Industry in the U. S. were in Chicago, Illinois, recently for the 32nd annual meeting of the American Petroleum Institute. The members snapped above were among the 6000 persons attending the sessions.

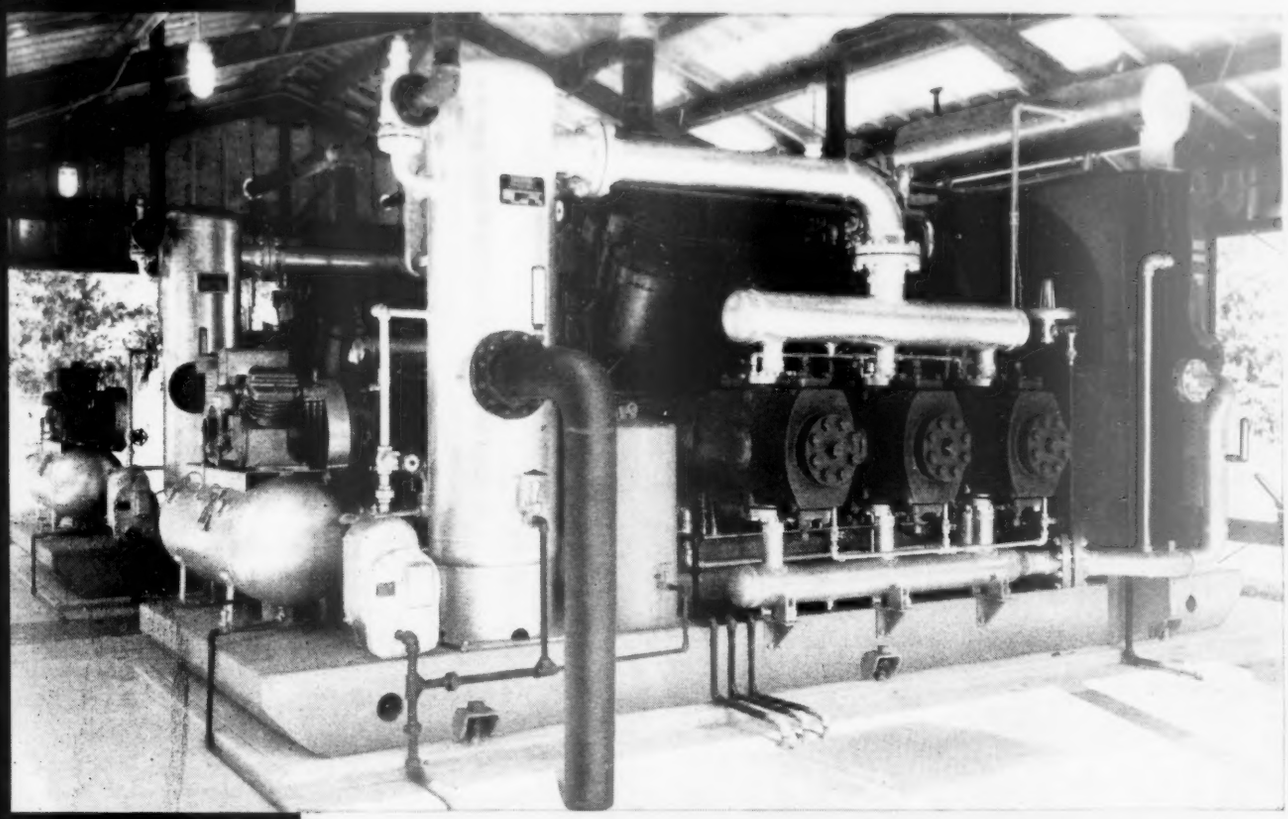
Nomads From All corners of the country met for lunch in Chicago, Illinois, during the recent American Petroleum Institute annual convention. Speaker at the meeting was R. L. Dudley, a charter member of Nomads from Houston, Texas.

Seated at the Speaker's Table at the Nomad luncheon during API meeting are: H. M. Cooley, regent, Tulsa; W. F. Bettis, acting regent, Los Angeles; H. B. Book, regent, New York; J. A. Engstrand, regent, Los Angeles; E. L. Lorehn, regent, Houston; C. J. Berlin, regent, Dallas; R. L. Dudley, charter member, Houston; J. A. Barnes, acting regent, Houston; G. F. Coons, regent, Tulsa; H. J. Wood, president, Houston chapter; W. A. Wilson, president, Los Angeles chapter, and Harry Estes, national executive secretary. Approximately 225 Nomad members met in the Crystal Ballroom of the Blackstone Hotel in Chicago.

For G
Flare
Field
or Re

XUM

BEAIRD-INGERSOLL-RAND PACKAGED COMPRESSOR PLANTS



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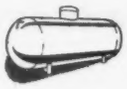
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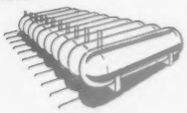
PRESSURE BULK STORAGE

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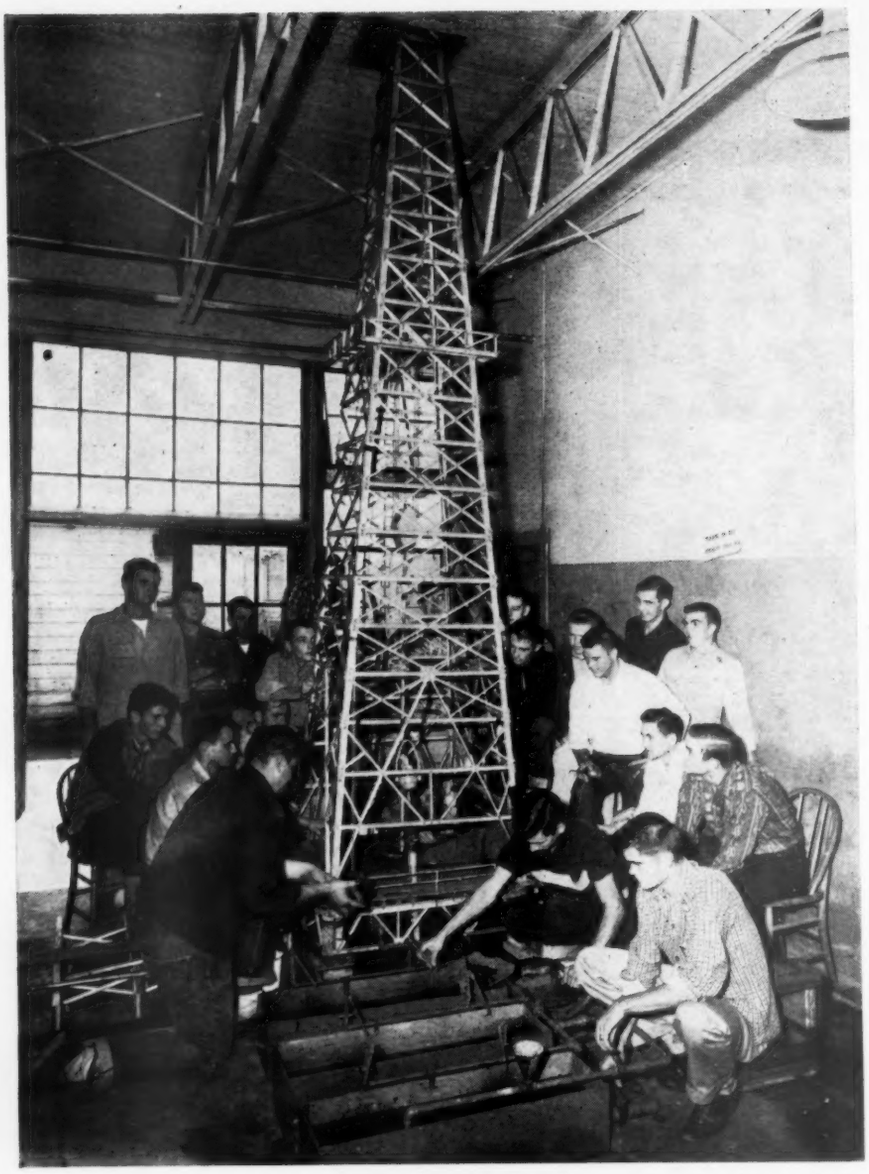

Working scale model drilling rig made by students.

Drilling Practice Course Aids Petroleum Industry

Basic knowledge of technical know-how combined with practical experience promotes efficiency

W. R. MAYS

IN January, 1947, at Kilgore College the first drilling practice course ever offered was established under the joint sponsorship of the American Association of Oilwell Drilling Contractors, and The University of Texas, Extension Division.

The purpose of this course was to supply the drilling industry with better trained employees. Originally, the course was set-up for 12 calendar months and included both classroom work and actual drilling rig operations. Classroom instruction included mathematics, chemistry, drilling mud, and rig equipment.

In September, 1951, in order to better meet the needs of both the students and the industry, the course was changed to a two semester, nine months course. The actual drilling rig instruction was eliminated and the course now consists of classroom and laboratory instruction. The classroom instruction is divided into the following courses: Chemistry, physics, slide rule, metallurgy, petroleum geology, rig equipment, well logging and drilling mud. Laboratory work is in chemistry, physics, and drilling mud.

The basic sciences, chemistry and physics, are taught to better prepare the students for the more advanced courses to follow, such as metallurgy, well logging, and drilling fluid. Many of the students have not had these sciences in high school, so the courses are designed to bridge the gap. Every effort is made to correlate the courses with the actual drilling job.

Slide rule is taught as a two-hour course.

The metallurgy course is offered in the second semester. Most of the time is spent on ferrous metallurgy from the mine through the blast furnace to the steel mills and the making of special alloys. Again the emphasis is placed on the subject as applied to the drilling operations. Properties and uses of other metals used in drilling are discussed. Some time is spent on corrosion problems.

Petroleum geology is also offered in the second semester. This course covers the origin of petroleum, suitable traps, properties, and its accumulation. Typical fields are discussed that illustrate the type of trap, contour maps, cross sections, method of discovery, geology, and production history. Some time is spent on methods of discovery and recovery mechanisms.

Rig equipment covers all the rotary drilling equipment in detail, for example, the power plant, the hoist, rotary

The Author

W. R. Mays is an instructor in drilling practices at Kilgore College, Kilgore, Texas. A graduate of the Missouri Schools of Mines and Metallurgy, Mays worked for East Texas Refining Company for 10 years as tester, clerk, plant superintendent, chemist, and instrument repairman. He spent two years as analytical chemist for Associated Refineries in Duncan, Oklahoma, and then three years as a sales and service engineer on plastic services for Halliburton Oil Well Cementing Company, Kilgore. He has been an instructor at Kilgore College since 1948.

EXCLUSIVE

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This new branch is in addition to the five Hercules branches located at Los Angeles, Calif., Salem, Ill., Houston, Odessa and Kilgore, Texas, and is to provide additional facilities for the increased demand of Hercules products. In addition the following Hercules distributors in the mid-continent area maintain adequate stocks of power units and parts for sales and service:

Food Machinery & Chemical Corp.
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El Paso, Texas

Kellet Industries
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Oilfield Motor Service
Alice, Texas

Lightbourn Equipment Co.
Dallas, Texas

Superior Iron Works & Supply Co.
Shreveport, Louisiana

Hercules—Lupfer Engine Sales Co.
Tulsa, Oklahoma

Gasoline, Natural Gas and Diesel Engines and Power Units

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Students mixing mud at Kilgore, Texas, college.

table, drilling string, drill collars, mud system, control instruments, deviation recorders, cementing, testing, and auxiliary equipment. To keep this material up-to-date liberal use is made of the leading oil journals, manufacturers' publications, movies, and equipment on loan from manufacturers.

The well logging course covers the basic principles of all types of subsurface evaluation. Electric logging is studied, and the electrode systems and their principle uses. Actual log interpretation is not emphasized as this is an engineering study. Other subsurface methods studied are caliper logging, radioactive logs, temperature logs, and mud and cutting analysis.

The drilling mud course is taught the entire nine months and is the most comprehensive. The first semester is devoted to water clay muds and the second semester to special mud systems. The students mix muds (see photo), contaminate and treat them. The uses and properties of the muds are discussed in class, field handling, lost circulation, heaving shale, and other problems. All the testing methods are used. This course is also kept up-to-date by the use of the oil journals and articles from the leading mud companies.

All the courses are helped by the liberal use of moving pictures provided by the steel companies, oil companies, equipment manufacturers, and service companies. Several field trips are made each year to equipment manufacturing plants. Classroom aids, on loan from companies, are drilling bits, floating equipment, wall cleaners, centralizers, deviation recorders, and others.

Drilling Rig Model

The most effective classroom aid is the 1/10 scale model drilling rig shown on page E-2. It was made by students of the machine shop and is operated by the drilling practice class. It has actually drilled about 30 ft at its classroom location. It is complete in every detail and is used by these students in actual practice. The catheads and mud pump are the only parts not made in the school shop. These items were made by the manufacturers of this equipment.

Originally, most of the students were veterans who came back to school to better prepare themselves for jobs. Some of the students are sent by their companies to train them for better jobs—engineers, tool pushers, etc. At the present time, a few Korean veterans are enrolling, but most of the students are recent high school graduates. Geographically, the students have been from Texas, Louisiana, and California. Other states represented include West Virginia, Mississippi, Michigan, New York, Florida, Oklahoma, Illinois, New Mexico, Indiana, and Arkansas. There have been two students from Venezuela.

About 180 students have finished this course and there are 25 enrolled at the present time. Those finishing this course have been employed by drilling contractors, service companies, supply houses, and drilling fluid companies. For the past year the most popular job choice has been with well logging crews for mud and cuttings analysis. Several of the graduates are working as mud engineers for one of the large service companies. A few have become drillers and tool pushers. Usually the students have a choice of jobs when they finish the course.

The overall purpose of the course is to turn out a better trained prospective employee. With the limited number of graduate engineers today there is an even more acute need for technically trained employees to carry part of the load of an industry that is rapidly becoming more technical. Drilling employees today must be better trained than ever before. With the type of training described here the student gets a general understanding of the industry and highly specialized training in equipment and drilling fluid. With a brief training period in company policy and a few job details the student should become a superior employee. ★ ★ ★

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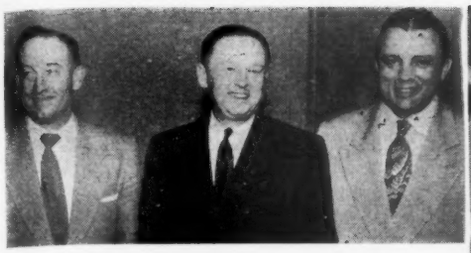

Los Angeles Nomads heard Major General D. H. Rudelson (above center) who spoke on Korea at the November meeting. With him are Bill Sargent (left) of Sargent Engineering, who presided, and Joe Schlarb of Chiksan Company, who introduced the General.

International guests at right are: Standing, Kenneth Smith, Trans-American Pipe Line, Iraq; Mario Cueto of Reed Roller Bit, Buenos Aires; Edmond M. Mong of Iraq Petroleum, Iraq; Ralph H. Connor of Transworld Management, formerly with IPC; Vincent W. Vandiver, foreign exploratory geologist with Seaboard. Seated, H. H. Mitchell of IPC from Basrah; C. H. Vincent of BMP (Shell); E. E. Higley of Ralph M. Parsons Company, back from China and going to South America; R. M. Long of IPC, from Iraq.

Independents Want Steel Controls Ended

Despite the pleas of a great majority of oil producers for decontrol of steel for the oil industry, the Petroleum Administration for Defense is standing firm on its belief that controls are necessary. Harris Bateman, head of PAD's material division, told the National Petroleum Council that PAD favors keeping controls on to make certain that all oil companies, both large and small, get a fair dent. Charlton H. Lyons, wrote J. Ed Warren recently that 424 members of IPAA showed they favor immediate decontrol and 162 opposed decontrol at this time. Lyons did not ask for immeamount of steel.

In a recent poll of the Independent Petroleum Association of America, more than two and one-half to one favored ending control immediately. IPAA presidiate decontrol, but requested that PAD "seek decontrol of oil country tubular goods as early as practical."

Warren, a former president of IPAA has indicated that he favors keeping on controls until shortages of steel have been eliminated. R. L. Foree, head of the production division, warned producers of continued shortages, and the steel industry itself has foreseen shortages of oil well steel.

F. W. Brigance, president of the American Association of Oilwell Drilling Contractors, has warned members of that organization that decontrol of oil country tubular goods "at this time" might bring hardships.

In a special bulletin, Brigance said the present inventory of tubular goods is the "lowest it has ever been," adding controls might be lifted satisfactorily by the end of the first quarter.

May World Output Down

World crude production in May, averaging 11,191,000 bbl daily, was only 90.4 per cent of the average rate in April, according to the Bureau of Mines. Principal contributor to the decrease was the United States, where daily average production in May, dropping as refinery strikes occurred, was 5,107,000 bbl compared to 6,429,000 in the previous month. During May, record daily average production rates occurred in Canada (180,000), Venezuela (1,844,000), Iraq (402,000), and Indonesia (182,000).

Imports of crude into western Europe averaged a record 1,370,000 bbl daily, an increase of 1.7 per cent over the April rate. A decline of 50,000 bbl daily in imports by the United Kingdom was offset by record daily movements of 442,000 and 180,000 into France and Italy respectively, as well as by a 47.8 per cent increase in daily average imports into the Netherlands during May.

Exports of crude from Venezuela in May averaged a record 1,534,000 bbl daily, compared to the previous rate of 1,511,000. Likewise a record daily average movement of 1,632,000 from the Middle East (exclusive of shipments to Bahrein) occurred during May, an increase of 3.4 per cent. Both Iraq and Kuwait exported at record daily average rates of 312,000 and 770,000 bbl.

Bahrein to Pay New Tax

The Bahrein Petroleum Company, Ltd., will have to pay a tax of 50 per cent on net income from the production and sale of Bahrein crude, retroactively to January 1, 1952. The new tax has been levied by the Bahrein ruler, who put it into effect December 15. Bahrein Petroleum is owned jointly by The Texas Company and Standard of California.

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News

PAD Allots Line Pipe For First Quarter 1953

The Petroleum Administration for Defense has allotted priorities for 235,553 tons of line pipe to pipe line and other projects for the first quarter of 1953. Fourteen large pipe lines will get 222,896 tons of the pipe, according to Interior Secretary Oscar L. Chapman.

PAD also announced that it does not think the time is ready for decontrolling oil country tubular goods. The steel industry has recommended such decontrol be put into effect by March 31.

One-hundred eighty-nine oil and gas operators have been granted individual allotments of 35,136 tons of conversion casing and tubing for the first quarter of 1953. A total of 8078 tons was allotted to 142 "A" operators—those who normally drill 40 or fewer wells in a 12-month period, and 27,058 tons were allotted to 47 "B" operators—those who normally drill more than 40 wells in a 12-month period.

California Oil Supply Dependent on Steel

Current shortages in California petroleum production can be overcome if enough oil country tubular goods to drill 3190 wells in the state are made available in 1953, an analysis by Oil Producers Agency of California shows.

The analysis, sent to Deputy Petroleum Administrator for Defense J. E. Warren by D. T. Staples, Oil Producers Agency president, calls upon the Petroleum Administration for Defense to consider the California petroleum situation an emergency and to take whatever steps are necessary to provide the materials to overcome it.

In order to meet estimated demands, including full military requirements which California production is at present unable to supply, 276,000 bbl of production per day will have to be developed in 1953, the analysis shows. This figure will offset the normal decline of producing fields and provide enough additional petroleum to bring total production to an average of 1,214,000 bbl daily, equal to the estimated 1953 average total daily demand, the agency declared.

Rising Imports Termed Threat to U.S. Economy

Oil imports should come into the United States "only in a manner and in such quantities that will not destroy the domestic oil industry," Russell B. Brown, Washington, D. C., general counsel of the Independent Petroleum Association of America, said in Albuquerque, New Mexico.

Speaking at the annual meeting of New Mexico Oil and Gas Association, Brown said increasing imports "present problems for solution in the near future that may prove far more serious than those that have confronted the industry for many years."

He recalled government efforts in 1929 to "close down the search for and development of oil in the United States" and to supply markets then supporting the domestic industry from foreign production. He said at that time imports had reached 10 per cent of total U. S. requirements, and exports amounted to about 15 per cent of requirements.

"That import position was improved through efforts of domestic producers until, in 1933, we were importing only 3.2 per cent of our total demand," he said, adding:

"Today we face accelerated imports that have climbed back to a rate of 12.5 per cent of total demand for the month of September 1952, with indication of further increases. Exports, except for oil to replace lost Iranian production, will be much lower percentagewise than at any previous time."

Brown declared rising imports "constitute a great threat to the domestic industry's ability to reach the proportions necessary to the nation's welfare."

NPC Storage Report Out

The National Petroleum Council has reported that the oil industry must have about 100 bbl of petroleum storage capacity to every 50 bbl of oil actually held in storage. Presented by L. S. Wescoat, president of Pure Oil Company, and chairman of the council's committee of petroleum storage capacity, the report was in response to a request made by PAD for up-to-date information on storage.

The study revealed that storage capacity of the oil industry had increased considerably in the last four years, particularly in the "clear" products group. Also in the "unavailable" inventories, such as those required to keep pipe lines filled and those in transit by tanker, barge, tank car, and truck had also grown.

Gasoline Price Down

Standard Oil Company of California has announced a reduction in the price of gasoline and other fuels in parts of Southern Idaho and Eastern Oregon. The price reduction ranges up to a half-cent per gallon for motor gasolines, diesel, and stove oils.

In making this announcement, Standard explained that increased volumes handled, and operating efficiencies in distribution have combined to make the lower prices possible. Standard reduced prices substantially in this area two years ago, on completion by a subsidiary of a pipe line from Salt Lake City, and at that time announced that further price reductions would be forthcoming in the future if operating economies permitted. Lower prices are also effective at bulk plants served by the terminals.

Discuss LPG Price Rise

Members of the Liquefied Petroleum Gas Industry Advisory Committee, at its first meeting with OPS officials, discussed requests for a higher ceiling price for liquefied petroleum gas sold from underground storage remote from producing plants.

Discussion centered around a proposal that gas sold from remote storage be granted an additional half-cent above the two-cent differential already provided under CPR 17 for gas sold from underground storage located adjacent to producing plants.

An over-all price increase because of increased costs in making, moving, and selling liquefied petroleum gas was also suggested by several members as a possible solution to their problems.

Crude Petroleum Stocks Dip Slightly

Stocks of domestic and foreign crude petroleum at the close of the week ended November 29 totaled 265,524,000 bbl, according to data reported to the Bureau of Mines, United States Department of the Interior. Compared with the total of 267,068,000 bbl for the preceding week, this represents a decrease of 1,544,000 bbl comprising a decrease of 1,089,000 bbl in stocks of domestic crude and a decrease of 455,000 bbl in stocks of foreign crude.

Stocks of crude petroleum November 1, 22, and 29, 1952. (thousands of barrels)

	November 1	November 22	November 29	Change from November 22	Change from November 1
Pennsylvania Grade	2,198	2,268	2,219	—49	21
Other Appalachian	1,984	1,838	1,844	6	—140
Lima–Michigan	643	602	588	—14	—55
Illinois–Indiana	11,577	11,440	11,483	43	—94
Arkansas	2,918	3,270	3,264	—6	346
Kansas	9,979	10,157	10,290	133	311
Louisiana	16,162	15,735	16,303	568	141
North	2,567	2,413	2,382	—31	—185
Gulf	13,595	13,322	13,921	599	326
Mississippi	2,993	3,072	3,016	—26	53
New Mexico	7,578	7,140	7,237	97	—341
Oklahoma	27,887	26,688	26,675	—13	—1,212
Texas:	129,891	131,820	129,827	—1,993	—64
East Texas Proper	12,393	12,065	11,721	—344	—672
West Texas	59,040	60,574	59,716	—858	676
Gulf Texas	26,186	26,430	25,926	—504	—260
Other Texas	32,272	32,751	32,464	—287	192
Panhandle	3,103	3,213	3,172	—41	69
North	7,308	7,547	6,843	—704	—465
South	5,882	5,868	6,245	377	363
Rest of State	15,979	16,123	16,204	81	225
Wyoming	12,563	12,085	12,292	207	—271
Other Rocky Mountain	2,557	2,534	2,376	—158	—181
California	31,594	30,527	30,643	116	—951
Foreign	8,011	7,892	7,437	—455	—574
Total crude stocks in U. S.	268,535	267,068	265,524	—1,544	—3,011
Total located in PAW District 1	17,813	17,352	17,057	—295	—756
Total located in PAW District 2	88,541	86,642	85,950	—692	—2,591

Prepared under the supervision of H. J. Barton, Petroleum and Natural Gas Economics Coordinator, Petroleum and Natural Gas Branch.

International Guests of Los Angeles Nomads recently were: W. J. Larson, Dunlap and Graham, Lima, Peru; H. F. Giles, Socony-Vacuum, Sumatra; G. E. Boyd, Baker Transworld, Edmonton, Canada; C. D. Hendershot of NPPM (Cal-Tex Pac), Sumatra. Seated, T. Vanderwert, Aramco, Dhahran, Saudi Arabia; Leslie Noell, Santa Fe Drilling, Lebanon; Fernando Nieri, Empresa Petrolera Fiscal, Zorritos, Peru; W. N. Thompson, Texas Petroleum, and Ray E. McNeil, Texaco, Colombia.

Oil Industry Pays Most Taxes, Report States

Staff members of the University of Texas Bureau of Business has reported that the State Legislature centers on gas, oil, and sulfur taxes and leaves other valuable natural resources of Texas without special taxes. Petroleum and its products, including gasoline, paid 65.6 per cent of all state taxes in Texas during 1950, the report stated. Natural gas transmission companies and utilities usually can shift the tax onto the consumer, but until the Federal Power Commission allows rate increases the gas companies must absorb the tax.

Chapman Is Honored With Testimonial Dinner

A testimonial dinner was given Interior Secretary Oscar L. Chapman recently by members of the National Petroleum Council, in appreciation of the support they have received from him in their attempt to keep the council a free body.

The citation by the group recalled that in 1946 Chapman first insisted that the council remain an independent body with an industrial chairman. He defended that stand five years later when the Department of Justice demanded that the council be placed under a governmental head. Carrying the fight to President Truman, Chapman convinced him that only by keeping it an all-industry body could the Government obtain full cooperation of the oil and gas industries.

In the course of the evening, Chapman presented the Conservation Service Award of the Department of the Interior to Walter S. Hallanan, president of Plymouth Oil Company, for his "invaluable work" for more than six years as chairman of the NPC. Chapman's letter of presentation read in part:

"In recognition of your wholehearted enthusiastic interest and the invaluable work you have done for over six years as chairman of the National Petroleum Council, it is a real pleasure to present to you the Conservation Service Award of the Department of the Interior."

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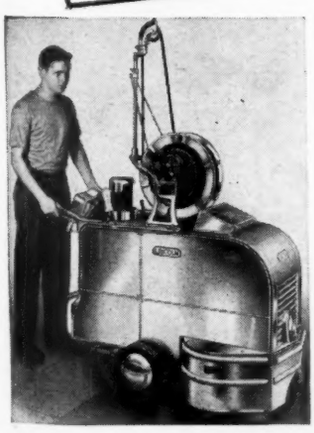

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Imports of Foreign Crude Stay at 1,000,000 Bbl Mark

Imports of foreign crude oil stayed over the 1,000,000 bbl per week mark December 6, after having gone over that figure October 18, the American Petroleum Institute reported.

Total imports were 1,049.400 bbl, slightly up from the 1,031,800 bbl for the week ended November 29.

Week ended	Crude oil	Residual oil	Others	Total
November 8.	513,000	411,800	3,600	928,400
November 15	751.600	335,300	12,800	1,099,700
November 22	655,300	342,800	23,200	1,021,300
November 29	645,100	358,700	28,000	1,031,800
December 6..	477,400	546,600	25,400	1,049 400

Exports for the weeks ending October 17, 24, 31, and November 7, and 14 are set out below in thousands of barrels a day by PAD:

	Avgas	Motor gasoline	Kerosine	Distillate	Residual	Total
October 17....	29.1	48.0	12.0	79.7	44.3	213.1
October 24....	30.5	22.1	8.5	145.0	69.5	275.6
October 31....	35.2	35.4	4.0	81.7	18.5	174.8
November 7...	41.1	72.7	14.2	106.0	36.1	270.1
November 14..	37.6	27.6	5.0	141.9	27.2	239.3

Dutch Refuse AIOC Files

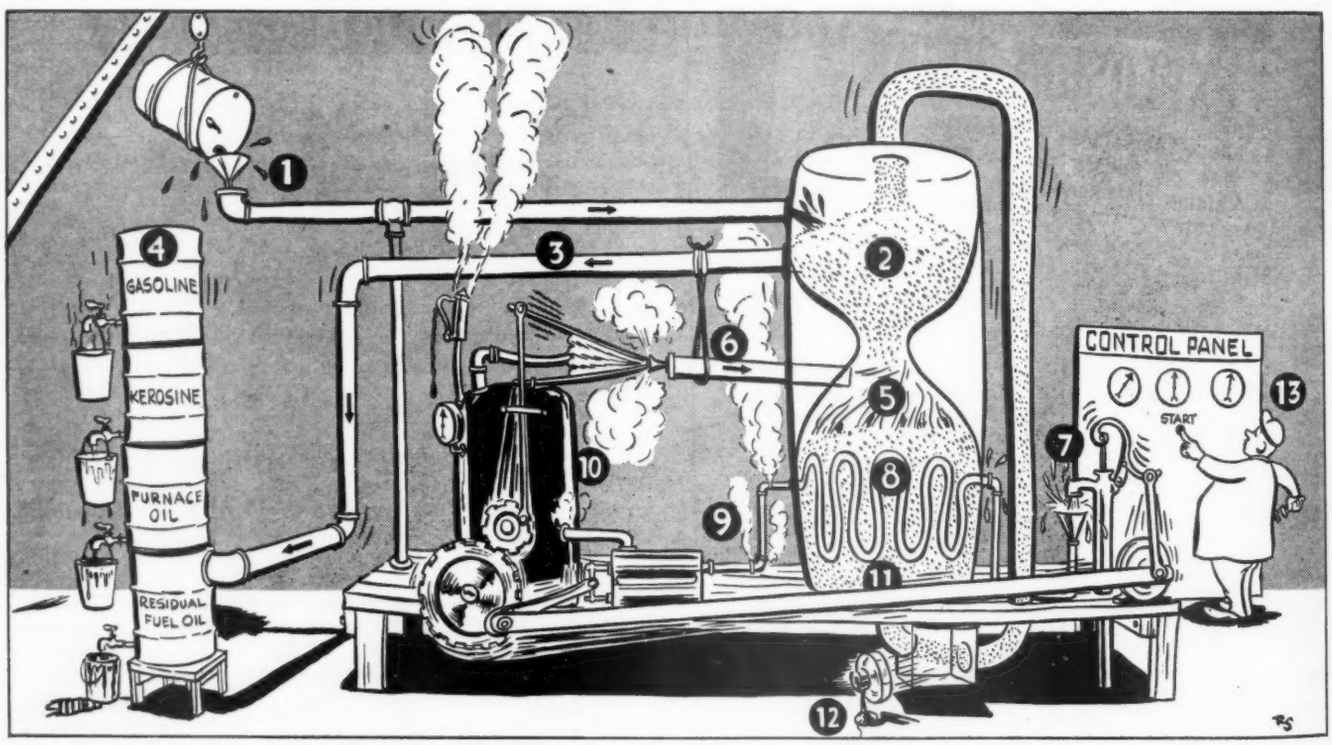
The Netherlands government has announced to the United States that it will not submit documents of oil companies established in that country to be used in the case against international oil cartels. The U. S. had demanded the files on the basis of American share holding in the companies based in the Netherlands. The Dutch government announced it was "concerned" about the way companies established in the Netherlands had been "indirectly" involved in the anti-trust action now going on in the U. S.

The communique from the Netherlands government did not identify the companies referred to but a foreign affairs office spokesman said it referred to subsidiaries of Standard Oil (New Jersey) and Caltex Petroleum.

The Anglo-Iranian Oil Company has been removed from the U. S. Government's investigation of the so-called world-wide oil cartel. The British-dominated company was declared as having "sovereign immunity." A subpoena in which the U. S. asked the company to produce various documents was automatically squashed by the ruling.

Stork Club in New York City was scene of recent Nomad party. Guests at the gathering were: R. W. Parker, California-Texas, Australia; Granville Parker, Texaco, Bogota, Colombia; E. C. Hendrix, International General Electric, Caracas, Venezuela; Dennis Slatford, Trinidad Oilfield Service, Trinidad, BWI; George Lockett, Mene Grande, Maracaibo; Carlos Bejarano, Motores, S. A., Bogota, and J. Feger, SNPA, Paris.

LAYMAN'S FLOW DIAGRAM OF HOUDRIFLOW UNIT



This is our artist's impression of how Toledo's big HCC unit operates. Oil to be cracked (1) enters reactor where (2) it comes in contact with hot catalyst and cracking takes place. (3) Cracked oil leaves reactor, goes to (4) fractionating tower. Catalyst flows downward into kiln (5) where air (6) is introduced to burn off carbon deposited on catalyst in cracking reaction. This is called regeneration. Water (7) is pumped through coils (8) around kiln to control heat of regeneration. The water becomes steam (9) which powers air blower (10) which supplies air for regeneration, which creates more heat to make more steam to supply more air, etc., etc. Meantime, regenerated catalyst leaves bottom of kiln (11) is picked up by air lift (12) and returned to top of reactor. (Actually, air which lifts catalyst is part of the air which has been used to burn carbon from the catalyst.) As you can see (13) the whole operation is controlled automatically by operator at a control panel.

From *Our Sun*, Sun Oil Company magazine.

MEMBERS SEEN AT API ANNUAL MEETING IN CHICAGO . . . . . .

Max E. Crawford
International Petroleum
Peru

S. C. Canary
Zephyr Petroleum

W. Camden
Camden Drilling

Henry E. Koopman
Phillips Petroleum

Charles A. Fisher
Chrysler Corporation

H. M. Cosgrove
Purchasing Agents
Association

John Babb
National Supply

C. B. Hussey
Gulf Oil

M. I. Taylor
Gulf Oil

M. E. Merkt, Jr.
Gulf Oil

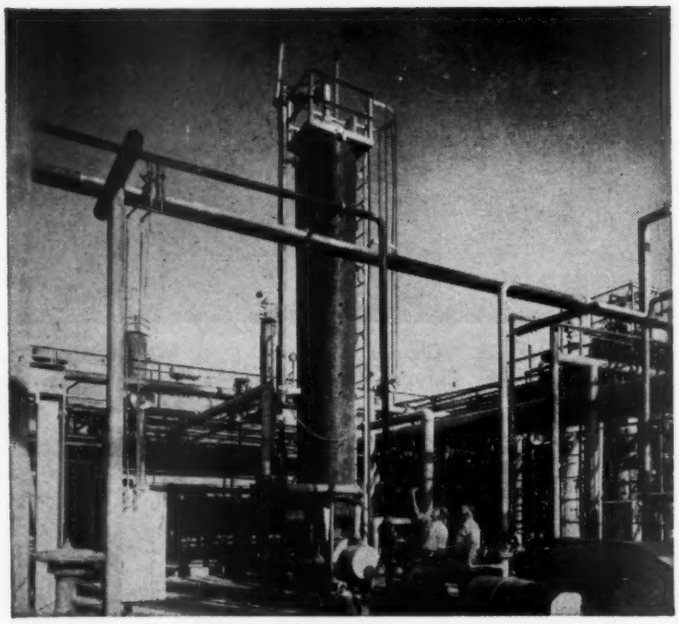
J. B. Steele
Kewanee Oil

Men of the Petroleum Industry in the U. S. were in Chicago, Illinois, recently for the 32nd annual meeting of the American Petroleum Institute. The members snapped above were among the 6000 persons attending the sessions.

Nomads From All corners of the country met for lunch in Chicago, Illinois, during the recent American Petroleum Institute annual convention. Speaker at the meeting was R. L. Dudley, a charter member of Nomads from Houston, Texas.

Seated at the Speaker's Table at the Nomad luncheon during API meeting are: H. M. Cooley, regent, Tulsa; W. F. Bettis, acting regent, Los Angeles; H. B. Book, regent, New York; J. A. Engstrand, regent, Los Angeles; E. L. Lorehn, regent, Houston; C. J. Berlin, regent, Dallas; R. L. Dudley, charter member, Houston; J. A. Barnes, acting regent, Houston; G. F. Coons, regent, Tulsa; H. J. Wood, president, Houston chapter; W. A. Wilson, president, Los Angeles chapter, and Harry Estes, national executive secretary. Approximately 225 Nomad members met in the Crystal Ballroom of the Blackstone Hotel in Chicago.

XUM



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PETROLEUM SERVICE DIVISION

Alice Maronde and J. W. McPhee, Lane-Wells, discuss plans for Long Beach Desk and Derrick Club.

Desk and Derrick

Alice Maronde, Lane-Wells Company, has been named president of the Long Beach, California, chapter of Desk and Derrick Club. A charter member of the Long Beach club, she is secretary to J. W. McPhee, Pacific Coast division manager of Lane-Wells. Edna Sellers, S. F. Fairfield, and Ann Hoffman, Union Oil, were elected first and second vice presidents; Kathy Kelly, Chicson, recording secretary, and Jessie Johnson, Richfield, treasurer. New directors are: Ruth Coolege, Long Beach Oil Development; Ruth Jenkins, D. D. Dunlap Oil; Iris Stoddard, Petrolite Corporation, and Zetta Belle Housely, Shell Oil.

Chicago oil women met recently to form the new Chicago Desk and Derrick chapter. Catherine A. Connell, The Texas Company, was named president. Other officers and directors elected were: Betty Raukin, Kanotex Refining, vice president; Victoria Trzeciak, Cities Service, recording secretary; Marilynn Sankevitz, Refiners Petroleum; Thelma Pike, Texas, treasurer; Valerie Koepke, TransAmerican Petroleum Products and Alyce Grace, Pure, directors for one year; Edna Waller, *Petroleum Marketer* magazine and Kathryn Brown, Pure, directors for two years.

Oil Men to Aid in Uranium Search

American oilmen have a plan whereby the oil industry's billion dollar-per-year hunt for oil can become as well a hunt for scarce and vital uranium, the raw material of atomic energy. The plan has been developed at the request of the U. S. Atomic Energy Commission.

This fact was revealed by Curtis H. Johnson, president of the Society of Exploration Geophysicists, who are developing a five-point program to ferret out radioactive minerals while the oil industry is searching for crude oil.

In discussing the plan, Johnson said it is now being presented to oil companies throughout the nation by a committee of the sponsoring groups who are also informing their scientist-members about their part in the plan.

The first of its several parts is based on this fact: Principal obstacle to discovering new supplies of uranium and thorium is limited range of detection instruments.

"Six inches of earth lying over a uranium deposit cuts the chances of it ever being discovered in half," Johnson stated.

But oil industry explorers drill over 4000 shallow test holes each day in the U. S. and Canada. The holes average 75 to 100 ft in depth, and are used for seismic testing of underground structures.

The first part of the plan, said the Geophysicists' president, calls for checking material excavated from shallow holes for radioactivity by special follow-up crews who would work behind the seismograph crews.

The other parts to the plan, worked out by a committee which also includes members from the AAPG and the SEPM, are:

All material drilled out in the first 500 ft in each of the 1000 or more oil wells drilled by the oil industry all over the nation each week be checked for radioactive materials in the same manner as the materials from shallow seismic exploration holes.

Another plan is that a radioactive device already used in oil well drilling, the gamma ray log, be utilized to check the first 500 ft of drilling, a process which is not usually followed in oil field practice as it is rarely of interest to oilmen.

▸ **W. B. Airth,** B.Sc., general manager of Ajax Petroleums, Ltd., since the company was formed, was elected president at a recent meeting of the board of directors. He will continue his duties as general manager of the company, as well as his dual duties as president and general manager of Ajax Alberta Pipeline, Ltd., a wholly-owned subsidiary of the oil company.

Airth replaces J. B. Adoue who resigned as president of Ajax Petroleums under pressure of other work. Adoue will remain as a director.

▸ **Charles R. Stevenson,** assistant treasurer and plant manager of Gulf Oil Corporation's Port Arthur, Texas, refinery has resigned after more than 50 years' service. He has been with Gulf all but one-half year of its 51-year existence, all of that service spent at the Port Arthur refinery.

At the age of 15, Stevenson joined Gulf as an office boy at its Port Arthur plant. Later he was promoted to stenographer, after taking summer courses at Tyler Business College, and subsequently was made assistant to the purchasing agent of the refinery.

In 1909, he was made purchasing agent and served in that capacity until 1929, when he was made plant manager of the company's three refineries in Texas and manager of the Gulf Commissary Company.

Stevenson was elected an Assistant Treasurer of Gulf Oil Corporation in 1938.

▸ **James R. Britt** recently joined Delta Engineering Corporation of Houston, Texas, to assume management of its con-

James R. Britt

struction division. In his new capacity, Britt will be responsible for the construction operations of an engineering contractor engaged in petroleum, petrochemicals, and natural gas facilities.

Britt entered the oil and gas field as a plant engineer for the Cities Service organization in 1936 after receiving his degree in chemical engineering from Louisiana State University. He was formerly superintendent of the natural gasoline division of Arkansas Fuel Oil Company.

During the period 1942 to 1945, Britt served in the U. S. Army, separating as a Major. He is a member of the American Institute of Chemical Engineers and the American Chemical Society.

H. B. Wiley, The Texas Company; R. J. Diwoky, Pan-Am Southern Corporation, and R. M. Stephens, Humble, at OIIC meeting in Dallas, Texas.

▸ **R. J. Diwoky,** executive vice president of Pan-Am Southern Corporation, became district chairman for the Oil Industry Information Committee at its meeting in Dallas, Texas, recently. He replaces Madison Farnsworth, Gulf Oil Corporation, former district chairman. His new vice chairmen are: **R. M. Stephens,** assistant sales manager, Humble Oil and Refining, and **H. B. Wiley,** division sales manager, The Texas Company.

Diwoky, Stephens, and Wiley will lead the 505 local OICC committees functioning in Alabama, Arkansas, Louisiana, Mississippi, New Mexico, and Texas with hundreds of volunteer workers drawn from all segments of the petroleum business.

G. R. Bryant, vice president of The Texas Company was named Texas chairman of OIIC.

▸ **Harold LeBurgeois** has been named to the business staff of *The Houston Post* to cover oil and gas news. Before joining *The Post*, LeBourgeois was oil news reporter for The Beaumont Enterprise, in addition to writing general business and industrial news. He is a graduate of the University of Texas where he majored in Journalism.

▸ **James C. Roberts** has been named assistant controller and **Eric C. Callahan** manager of accounting in the controller's department of Mid-Continent Petroleum Corporation. Roberts will succeed Turner L. Smith. Callahan's position is a newly formed one.

Roberts attended St. Louis University and Tulsa University and was formerly with Standard Fruit and Steamship Company. Callahan joined the Cosden Companies (now Mid-Continent) in 1919. He has held various positions with Mid-Continent during his 33 years with the company, and most recently was in charge of consolidated balance sheet and income records in the accounting department.

▸ **Governor Edward F. Arn,** of Kansas, has been elected chairman of the Interstate Oil Compact Commission, and **Earl Foster** of Oklahoma City, re-elected executive secretary.

The 22-state conversation agency met in Wichita, Kansas, recently, where members were told by Arn, that in his opinion president-elect Eisenhower will support its view on oil and gas development on public lands. The Commission offered its support to Douglas McKay, Eisenhower's secretary of Interior-designate, for the coming session.

▸ **Hial B. Gernert** of Casper, Wyoming, has been elected to membership on the National Petroleum Council. Gernert is the newly elected president of the Rocky Mountain Oil and Gas Association.

▸ **Paul L. Kartzke** has been appointed a vice president of Shell Oil Company. In his new capacity, he will continue to

Paul L. Kartzke

direct Shell's search for new oil reserves and the production of oil and gas in western Canada, with headquarters in Calgary, Alberta. Kartzke has been exploration and production manager for Shell Oil Company in the Calgary area and vice president of Shell Oil Company of Canada, Ltd.

He joined Shell in 1935 as a junior engineer in Ventura, California, shortly after his graduation from California Institute of Technology, where he received his Master's Degree in civil engineering. He was promoted to the post of division manager in the Rocky Mountain area in 1948, where he was in charge of Shell's exploration campaign in the Williston Basin.

Personals

Guests of the Houston Nomads during a recent meeting were: W. G. Berry, A-Z Export, South America, Maracaibo, Venezuela; T. P. Whittaker, National Supply Export, New York City; H. W. R. Wardlaw, Asiatic Petroleum, Houston; William Golden, CIMA, Mexico City, and Orlan G. Webb, Baker Transworld, Maracaibo.

▸ **J. Avery Guyton,** regional manager of Gulf Oil Corporation, with headquarters in Jacksonville, Florida, has announced his resignation. Guyton has had many years' experience in the petroleum industry, including 12 with Gulf. He plans to conduct a fuels consulting business in Jacksonville, Florida.

▸ **Hal R. Yockey** has been named advertising manager for Pan-Am Southern Corporation. Yockey succeeds the late Kenneth A. Rotharmel, advertising manager for Pan-Am for 26 years, who died recently. Yockey was a member of the news staff of The Times-Picayune before joining Pan-Am in 1951. He served in Iran as Persian Gulf Command editor for the Army newspaper, Stars and Stripes.

Yockey joined the oil company as editor of publications in 1951. He began the "Pan-Am Southerner," a monthly magazine which received one of the four top awards of the SAIE.

▸ **Bruce F. Grant,** formerly of the U. S. Bureau of Mines, has joined the Sinclair Research Laboratories, Inc., as director, petroleum engineering division. He will

Bruce F. Grant

make his headquarters at the company's laboratories in Tulsa, Oklahoma.

Prior to joining the Sinclair organization, Grant was section chief in petroleum engineering, petroleum and natural gas production branch, Franklin, Pennsylvania, USBM, and recently was in charge of designing and planning petroleum research facilities at the New Morgantown. West Virginia, station of the Bureau of Mines.

Grant has had wide experience in secondary recovery methods and in his position with Sinclair will devote his time largely to research in this field.

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Needed by major Pipe Line Company in Tulsa, Oklahoma. State age, education, experience, and salary expected. Steady employment to capable men. Write Box 147, care of THE PETROLEUM ENGINEER, P. O. Box 1589, Dallas, Texas.

Young man, 25, graduate, University of California, Bachelor of Chemical Engineering; 3-month course in topographic surveying; veteran, U. S. Army; surveying experience, post engineers, Ladd Field, Alaska; experience in steam engine and high pressure turbine work, would like job in petroleum and petro-chemicals field. Willing to go outside U. S. Harold E. Musgrove, care Department Chemical Engineering, University Southern California, References.

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Professor Vladimir N. Ipatieff, director of research for Universal Oil Products Company, passed away November 29. Dr. Ipatieff was also director of the high pressure and catalytic laboratory at Northwestern Technological Institute, in Evanston, Chicago suburb.

Already famous for his chemical research achievements before he left Russia in the early 1930's, his greatest work was carried out in this country, largely on hydrocarbon reactions and syntheses, and the application of catalysis to petroleum and other hydrocarbon processing. In collaboration with Dr. Vladimir Haensel, one of his outstanding proteges, these two developed syntheses for triptane, or i-propyl-i-butane, an important high octane number hydrocarbon constituent of aviation fuel that was very useful in World War II aviation successes for the Allies. He was foremost also in the development of processes for alkylation, isomerization, and the polymerization of olefins to motor and aviation fuel components.

Dr. Ipatieff was born in Moscow, Russia, in 1867, and graduated from the Czarist Artillery Academy in 1892. He had always been engrossed in chemistry and in 1896 was sent to Germany and France for graduate study in this science. Among his numerous honors and awards for his accomplishments are included the Willard Gibbs Medal, in 1940 by the American Chemical Society, and two recent French citations, one making him a Chevalier of the Cross of Loraine and a Companion of the Resistance, the other—an appointment as a member of the French Association of the Knights of Cyprus and Jerusalem. He refused to return to Russia in 1936 at the command of the Communist Government, which thereupon denounced him as "A hireling of the capitalists." Since coming to America he has contributed more than $56,000 to the furtherance of the work of the laboratory at Northwestern which bears his name.

In honor of his outstanding contributions to the science of chemistry over a period of 60 years Universal Oil Products Company has established the Ipatieff Research professorship of organic chemistry at Northwestern University, and has made the initial grant of $25,000 per year for three years. Ipatieff also initiated the $3,000 Ipatieff Prize in Chemistry, awarded every three years by the American Chemical Society to a chemist under 40 years old.

He is survived by Varvara Ipatieff, his widow, and a son and a daughter, both now understood to be living behind the Iron Curtain in Russia.

Dr. John M. Pearson, director of production physical and development research for Sun Oil Company, died November 16 at his home in Swarthmore, Pennsylvania. Dr. Pearson was the author of several articles on electrical measurement on corrosion, cathodic protection engineering, static electricity and electronics.

In 1948, he received the Dr. Frank Newman Speller Award for his work in the corrosion field from the National Association of Corrosion Engineers. He was a member of the association's board of directors and executive committee.

Dr. Pearson attended Reed College in Portland, Oregon, for two years and then transferred to the University of Chicago.

He returned to Sun Oil in 1945 and became director of the company's physical laboratory at Upland, near Chester, Pennsylvania, before the company's modern laboratory was built at Newton Square, near Philadelphia.

Warren A. Sinsheimer, veteran Cities Service executive, died November 28 at his home in Harrison, New York, after a long illness. Sinsheimer entered the oil business in 1907, following his graduation from the University of California. In 1927 he became associated with the Cities Service organization and for many years was manager of the oil pipe line and production department in New York. At the time of his death he was coordinator of economics for Cities Service.

William B. Shanley, West Coast representative for Universal Oil Products Company, died November 19. Shanley had been with Universal for more than 22 years, joining the company in 1930, immediately following his graduation from the University of Notre Dame where he received a MS degree in chemical engineering.

During his years with Universal, Shanley was particularly active in the operation of polymerization, isomerization, and alkylation units.

Clarence E. Kinney, prominent for many years in the naval stores industry, died November 25 in Kansas City, Missouri. Kinney was assistant to the director of operations of the Naval Stores department of Hercules Powder Company in Wilmington, Delaware, prior to his retirement in 1945. He was graduated from the University of Michigan with a degree in chemical engineering in 1905.

Robert Edwin Kirn, vice president and general sales manager of the C. Lee Cook Manufacturing Company, Inc., died on November 11 in Louisville. Kirn was formerly with the American Elevator and Machine Company. In 1919 Kirn went to work for C. Lee Cook as a sales engineer. Subsequently, he was promoted to general sales manager of the company and vice president.

Al Buchanan, oil man and drilling contractor, died in Wichita Falls, Texas, November 30. Buchanan had worked in all phases of oil production. He had been tool pusher, roughneck, and driller. He began his career in the oil business as a roughneck in the Petrolia fields near Wichita Falls in 1908, and was on hand at the major booms in the Southwest.

John Benton Brewer, former oil editor of the San Angelo Standard-Times, died December 12. Brewer retired from the paper in September due to ill health. He had been editor of the Standard-Times for 29 years.

Proof of Top Preference for

WISCONSIN HEAVY-DUTY *Air-Cooled* **ENGINES**

Based on data contained in a "Facts for Industry" report released on Sept. 5, 1952 by the U. S. Bureau of the Census, an aggregate average of 50.61% of all carburetor type internal combustion engines produced during 1950-'51 within an 11 to 175 cu. in. displ. range (approx. 3 to 40 hp.) were WISCONSIN HEAVY-DUTY AIR-COOLED ENGINES (exclusive of aircraft, automotive, outboard marine and "captive" engines built by various manufacturers for use on their own equipment).

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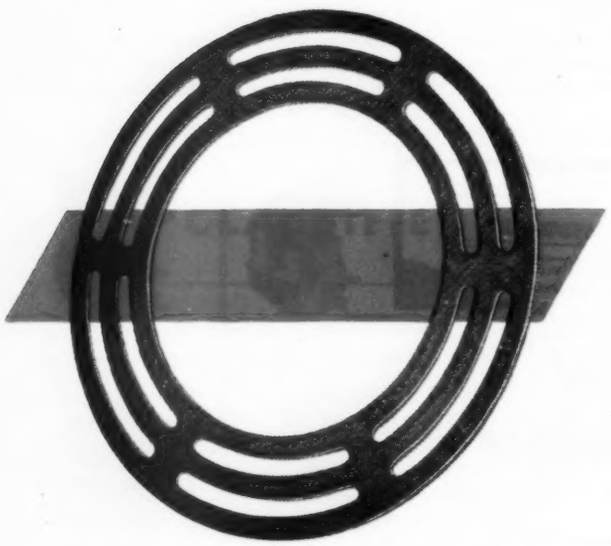

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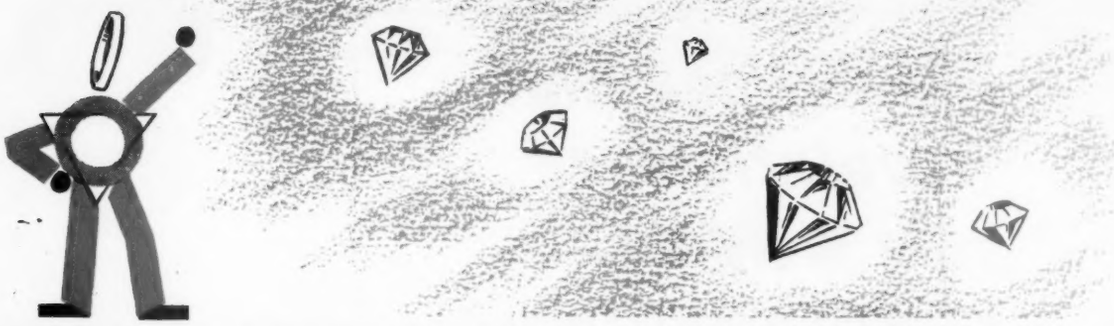

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In the year 1931 Taylor Forge gave industry its *first real line* of seamless, butt-welding pipe fittings. We say it was the first *real* line because it was the first to include not only long and short radius ells, but also full branch and reducing tees, concentric and eccentric reducers, stub ends, caps and welding neck flanges.

This was a fully planned development. Many years before Taylor Forge had foreseen the future of the butt-welding fitting . . . had realized that pipe welding could not go beyond its then crude stage until pipe users were given *all* the fittings necessary to make up complete piping systems.

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TON MILES — 3½-in. drill pipe — 13.3 lb. per foot

55,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	2	4	6	9	11	13	15	18	20
1000	22	24	26	29	32	34	36	39	41	44
2000	46	49	52	54	56	59	62	65	68	70
3000	73	76	79	81	84	87	90	93	96	99
4000	102	105	108	111	114	117	120	123	127	130
5000	133	136	139	143	146	149	153	156	159	163
6000	166	170	173	177	180	184	187	191	194	198
7000	202	205	209	213	217	220	224	228	232	236
8000	240	243	247	251	255	259	263	267	271	276
9000	280	284	288	292	296	300	305	309	313	318
10000	322	326	331	335	339	344	348	353	357	362
11000	366	371	376	380	385	390	394	399	404	409
12000	413	418	423	428	433	438	442	447	452	457
13000	462	467	472	477	483	488	493	498	503	508
14000	514	519	524	529	535	540	545	551	556	561
15000	567	573	578	584	589	595	600	606	612	617
16000	623	629	634	640	646	652	657	663	669	675
17000	681	687	693	699	705	711	717	723	729	735
18000	741	747	754	760	766	772	778	785	791	797
19000	804	810	817	823	829	836	842	849	855	862

60,000 lb EXCESS WEIGHT

0	0	2	3	6	9	12	14	17	19	21
1000	24	26	29	32	34	37	39	42	45	47
2000	50	53	56	58	61	64	67	70	73	76
3000	79	82	85	88	91	94	97	100	103	106
4000	109	113	116	119	122	126	129	132	136	139
5000	142	146	149	153	156	160	163	167	170	174
6000	178	181	185	189	192	196	200	204	207	211
7000	215	219	223	227	231	235	239	243	247	251
8000	255	259	263	267	271	276	280	284	288	293
9000	297	301	306	310	314	319	323	328	332	337
10000	341	346	350	355	359	364	369	373	378	383
11000	388	392	397	402	407	412	417	422	426	431
12000	436	441	446	451	457	462	467	472	477	482
13000	487	493	498	503	508	514	519	524	530	535
14000	541	546	552	557	563	568	574	579	585	591
15000	596	602	608	613	619	625	631	636	642	648
16000	654	660	666	672	678	684	690	696	702	708
17000	714	720	726	732	739	745	751	757	764	770
18000	776	782	788	794	801	807	814	820	827	833
19000	840	846	853	860	866	873	880	886	893	900

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 3½-in., 13.3 lb drill pipe and 55,000 lb excess weight = 438.

TON MILES — 4-in. drill pipe — 14.0 lb. per foot

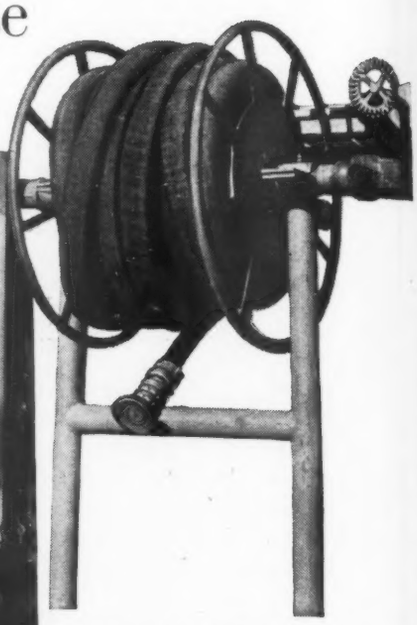
15,000 lb EXCESS WEIGHT

0	0	1	1	2	3	3	4	5	5	6
1000	7	8	9	10	11	12	12	13	15	16
2000	17	18	19	20	21	22	24	24	26	27
3000	29	30	31	33	34	36	37	39	40	42
4000	43	45	46	48	50	51	53	55	57	58
5000	60	62	64	66	68	70	72	74	76	78
6000	80	82	84	86	88	91	93	95	97	100
7000	102	104	107	109	111	114	116	119	121	124
8000	127	129	132	134	137	140	142	145	148	151
9000	154	157	159	162	165	168	171	174	177	180
10000	183	186	189	193	196	199	202	206	209	212
11000	215	219	222	226	229	232	236	239	243	246
12000	250	254	257	261	265	268	272	276	279	283
13000	287	291	295	299	303	307	311	315	319	323
14000	327	331	335	339	343	348	352	356	360	365
15000	369	373	378	382	386	391	395	400	404	409
16000	414	418	423	427	432	437	441	446	451	456
17000	461	466	470	475	480	485	490	495	500	505
18000	510	515	521	526	531	536	541	547	552	557
19000	563	568	573	579	584	590	595	600	606	612

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 4-in., 14.0 lb drill pipe and 15,000 lb excess weight = 268.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

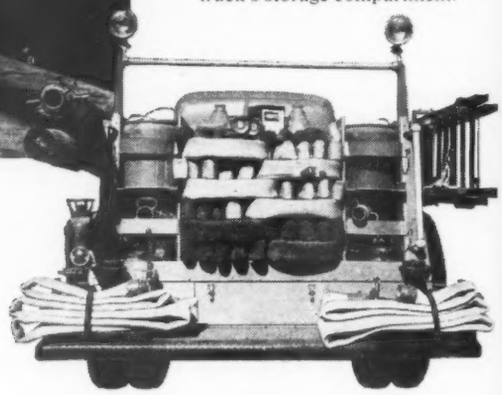
Maintenance men and firefighters rely on U. S. Rubber Hose



Above is a "U. S." neoprene-covered fire hose in a refinery. It is resistant to sun, chemicals, oil, abrasion and mildew. It has the popular fog nozzle.

(left) **"U. S." hose** used for fire fighting as well as general wash-down purposes.

(below) **U. S. Matchless Carbolized** fire hose can handle 500 gallons per minute. Note how its flexibility allows it to be folded into the truck's storage compartment.



Many a leading modern refinery depends on "U. S." hose of several types to help protect against fire. Each hose is specially designed and built to handle a definite set of working conditions. Highest grade materials, scientifically compounded rubber, uniformity of construction, skilled workmanship – these are the secret of "U.S." hose superiority. For extra special circumstances, "U.S." engineers will develop hose to meet your requirements. Write to address below.

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TON MILES

4-in. drill pipe — 14.0 lb. per foot

20,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	1	2	2	3	4	5	6	7	8
1000	9	10	11	12	13	14	16	17	18	19
2000	20	22	23	24	26	27	29	30	31	33
3000	34	36	37	39	41	42	44	46	47	49
4000	51	53	54	56	58	60	62	64	66	68
5000	70	72	74	76	78	80	82	85	87	89
6000	91	94	96	98	101	103	105	108	110	113
7000	115	118	120	123	125	128	131	134	136	139
8000	142	144	147	150	153	156	159	162	164	168
9000	171	174	177	180	183	186	189	193	196	199
10000	202	206	209	212	216	219	222	226	229	233
11000	236	240	243	247	251	254	258	261	265	269
12000	273	277	280	284	288	292	296	300	304	308
13000	312	316	320	324	328	332	336	341	345	349
14000	353	358	362	366	371	375	379	384	388	393
15000	397	402	405	411	416	420	425	430	434	439
16000	444	449	453	458	463	468	473	478	483	488
17000	493	498	503	503	513	518	524	529	534	539
18000	544	550	555	560	566	571	577	582	588	593
19000	599	604	610	615	621	627	632	638	644	649

25,000 lb EXCESS WEIGHT

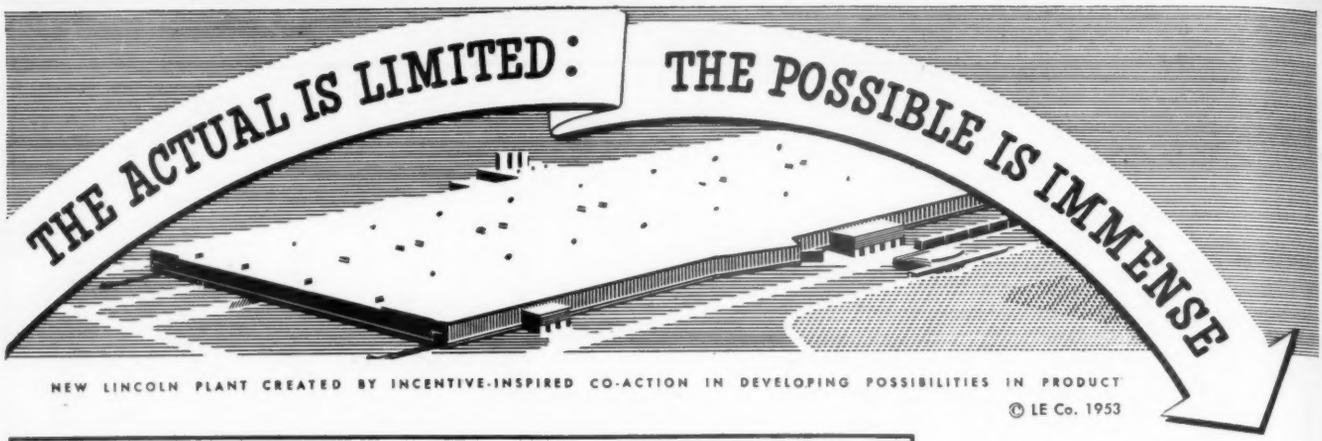
0	0	1	2	3	4	5	6	7	8	9
1000	11	12	13	15	16	17	19	20	21	23
2000	24	26	27	29	30	32	33	35	37	38
3000	40	42	44	45	47	49	51	53	55	57
4000	58	60	62	64	66	69	71	73	75	77
5000	79	82	84	86	88	91	93	95	98	100
6000	103	105	108	110	113	115	118	120	123	126
7000	129	131	134	137	140	142	145	148	151	154
8000	157	160	163	166	169	172	175	178	181	185
9000	188	191	194	198	201	204	208	211	214	218
10000	221	225	228	232	235	239	242	246	250	253
11000	257	261	265	268	272	276	280	284	288	292
12000	296	299	303	308	312	316	320	324	328	332
13000	336	341	345	349	353	358	362	367	371	375
14000	389	394	398	403	407	412	417	421	426	431
15000	435	440	445	449	454	459	464	469	474	479
16000	474	479	484	489	494	499	504	509	515	520
17000	525	530	536	541	546	552	557	562	568	573
18000	579	584	590	595	601	606	612	617	623	629
19000	635	640	646	652	658	663	669	675	681	687

30,000 lb EXCESS WEIGHT

0	0	1	2	4	5	6	7	9	10	11
1000	13	14	16	17	19	20	22	23	25	26
2000	28	30	31	33	35	37	38	40	42	44
3000	46	38	50	52	54	55	58	60	62	64
4000	66	68	70	73	75	77	79	82	84	86
5000	89	91	94	96	98	101	104	106	109	111
6000	114	117	119	122	125	128	130	133	136	139
7000	142	145	148	151	154	157	160	163	166	169
8000	172	175	178	182	185	188	191	195	198	201
9000	205	208	212	215	219	222	226	229	233	237
10000	240	244	247	251	255	259	263	266	270	274
11000	278	282	286	290	294	298	302	306	310	314
12000	318	322	327	331	335	339	344	348	352	357
13000	361	365	370	374	379	383	388	392	397	401
14000	406	411	416	420	425	430	435	440	444	449
15000	454	459	464	469	474	479	484	489	494	499
16000	505	510	515	520	525	531	536	541	547	552
17000	557	563	568	574	579	585	590	596	601	607
18000	613	618	624	630	636	641	647	653	659	665
19000	671	676	682	688	694	700	706	712	719	725

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 4-in., 14.0 lb drill pipe and 25,000 lb excess weight = 316.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

© LE Co. 1953

MOBILE UNIT DOUBLE JOINTING SPEEDS PIPE LAYING

By: **EDWIN G. HILL**
Vice-President, HILLCO, Inc.,
Tulsa, Oklahoma

AN average of eight 26″ double-jointing welds per hour are being completed with the new mobile machine. One crew first aligns the pipe with an internal clamp and runs the manual root bead. The pipe is then picked up and placed on turning rolls for final welding by the mobile unit using "Manual Lincolnweld" arc welding in granular flux. Welding speed is 36 inches per minute for each of two passes. The final weld, ⅝″ to ¾″ wide, is slightly convex with feather edge appearance at the junction of the pipe.

Mounted on a diesel tractor, the mobile double jointing unit is equipped with a 600 amp. Lincoln "Shield-Arc" generator direct driven from the tractor power takeoff. The "Manual Lincolnweld" unit itself is mounted on a platform attached to the tractor, and is hydraulically elevated to accommodate various pipe levels. Unused granular flux is salvaged by a vacuum flux recovery unit.

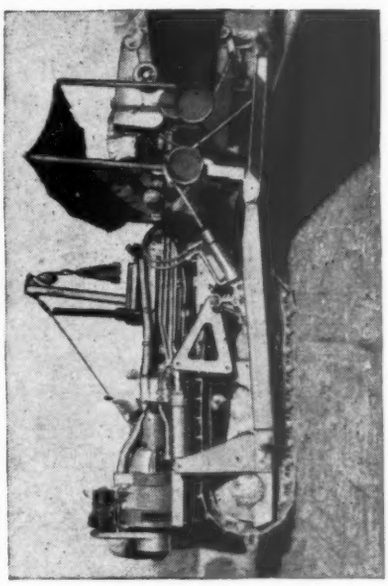


Fig. 3. Mobile double-ender *used on the Oklahoma Natural Gas 26″ pipe line. Built by HILLCO, Inc., Tulsa, Oklahoma, it produces 60 to 70 thirty-inch pipe welds per day.*

CUTS WELDING COSTS 25%

Fig. 1. Double jointing *26″ pipe along the right of way with "Manual Lincolnweld". Cuts costs of welds by 25%.*

SAVES 40% ON ELECTRODES

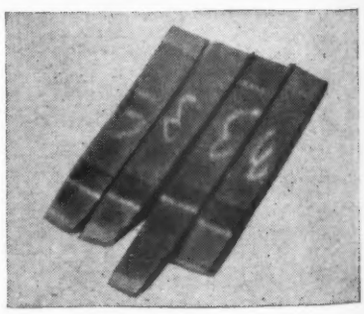


Fig. 2. Hidden arc welding *in granular flux assures uniform quality on every joint when checked by X-rays.*

WELDS 4 TIMES FASTER

Send for Bulletin 1303 "Manual Lincolnweld". Write to Dept. 189,

THE LINCOLN ELECTRIC COMPANY
CLEVELAND 17, OHIO

TON MILES

4-in. drill pipe — 14.0 lb. per foot

35,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	1	3	4	6	7	8	10	12	13
1000	15	16	18	20	21	23	25	26	28	30
2000	32	34	35	37	39	41	43	45	47	49
3000	51	54	56	58	60	62	64	67	69	71
4000	74	76	78	81	83	86	88	91	93	96
5000	98	101	103	106	109	111	114	117	120	123
6000	125	128	131	134	137	140	143	146	149	152
7000	155	158	161	164	168	171	174	177	181	184
8000	187	191	194	197	201	204	208	211	215	218
9000	222	226	229	233	236	240	244	248	251	255
10000	259	263	267	271	275	279	283	287	291	295
11000	299	303	307	311	315	320	324	328	332	337
12000	341	345	350	354	359	363	367	372	376	381
13000	386	390	395	400	404	409	414	418	423	428
14000	433	438	443	447	452	457	462	467	472	478
15000	483	488	493	498	503	508	514	519	524	530
16000	535	540	546	551	556	562	567	573	578	584
17000	590	595	601	606	612	618	624	629	635	641
18000	647	653	659	664	670	676	682	688	694	700
19000	707	713	719	722	731	737	744	750	756	762

40,000 lb EXCESS WEIGHT

0	0	2	3	5	6	8	10	11	13	15
1000	17	18	20	22	24	26	28	30	32	34
2000	36	38	40	42	44	46	48	50	53	55
3000	57	59	62	64	66	69	71	74	76	79
4000	81	84	86	89	92	94	97	99	102	105
5000	108	111	113	116	119	122	124	128	131	134
6000	137	140	143	146	149	152	155	159	162	165
7000	168	172	175	178	182	185	188	192	195	199
8000	202	206	210	213	217	220	224	228	231	235
9000	239	243	247	250	254	258	262	266	270	274
10000	278	282	286	290	294	298	303	307	311	315
11000	320	324	328	333	337	341	346	350	355	359
12000	364	368	373	377	382	387	391	396	401	406
13000	410	415	420	425	430	435	439	444	449	454
14000	459	464	470	475	480	485	490	495	500	506
15000	511	516	522	527	532	538	543	549	554	560
16000	565	571	576	582	588	593	599	604	610	616
17000	622	628	633	639	645	651	657	663	669	675
18000	681	687	693	699	705	711	718	724	730	736
19000	743	749	755	761	768	774	781	787	794	800

45,000 lb EXCESS WEIGHT

0	0	2	4	5	7	9	11	13	14	16
1000	18	20	22	24	26	29	31	33	35	37
2000	39	42	44	46	48	51	53	55	58	60
3000	63	65	68	70	73	75	78	81	83	86
4000	89	91	94	97	100	103	106	108	111	114
5000	117	120	123	126	129	132	135	139	142	145
6000	148	151	155	158	162	165	168	171	175	178
7000	182	185	188	192	196	199	203	207	210	214
8000	218	221	225	229	233	237	240	244	248	252
9000	256	260	264	268	272	276	280	284	289	293
10000	296	301	306	310	314	318	323	327	332	336
11000	341	345	349	354	359	363	368	372	377	382
12000	387	391	396	401	406	410	415	420	425	430
13000	435	440	445	450	455	460	465	470	476	481
14000	486	491	497	502	507	512	518	523	529	534
15000	539	545	550	556	562	567	573	578	584	590
16000	594	601	607	613	619	624	630	636	642	648
17000	654	660	666	673	678	684	690	696	703	709
18000	715	721	728	734	740	746	753	759	766	772
19000	779	785	792	798	805	811	818	825	831	838

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 4-in., 14.0 lb drill pipe and 35,000 lb excess weight = 363.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

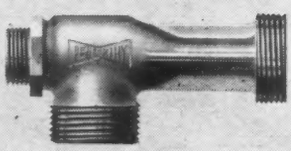
PENBERTHY *Jet Pumps*

(EJECTORS • EDUCTORS • EXHAUSTERS • SYPHONS)

Often the MOST ECONOMICAL and EFFICIENT WAY to Transfer and Mix Fluids

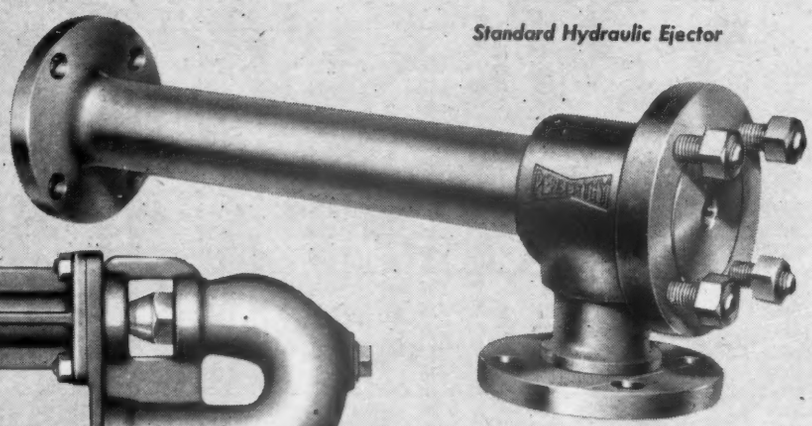
The jet pump is a simple device which uses steam, water or air under pressure to pump (or mix) fluids that can include solids in suspension. Jet pumps have no moving parts, need no lubrication, have no packing glands, are practically noiseless. They are low in initial cost and installation cost . . . compact in size and trouble-free. Penberthy offers a variety of jet pumps for a wide range of ordinary and unusual applications. They can be made from materials that withstand corrosion, contamination and high temperatures. Ask for new Bulletin 512.

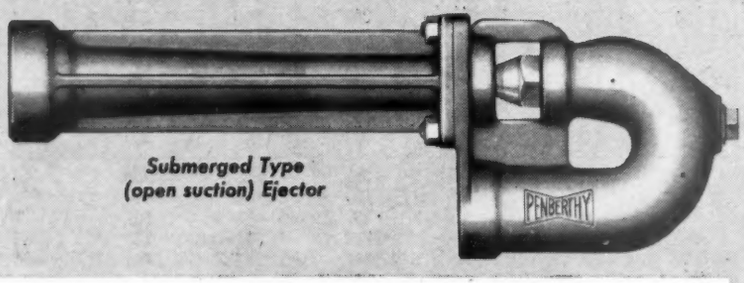
Standard Ejector for Steam or Air Operation



Standard Hydraulic Ejector

Stainless Steel Jet Pump for Handling Corrosive Chemicals

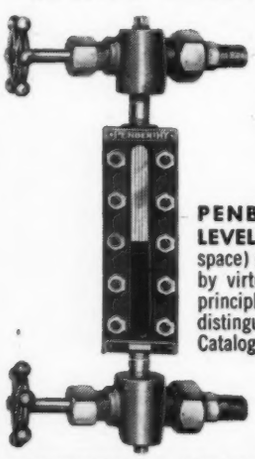




Submerged Type (open suction) Ejector

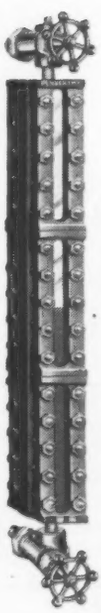
WRITE FOR *New* BULLETIN No. 512

OTHER PENBERTHY PRODUCTS



PENBERTHY TRANSPARENT LIQUID LEVEL GAGE—Used to observe color and density of liquids under high pressures and/or temperatures. Exceptionally sturdy construction—liquid chamber machined from solid block of metal. Ask for Catalog 35.

PENBERTHY REFLEX LIQUID LEVEL GAGE—Empty space (or steam space) shows white and liquid shows black by virtue of a simple, unvariable optical principle. Accurate reading as far as you can distinguish black and white. Write for Catalog 35.



PENBERTHY AUTOMATIC INJECTOR—Will supply feed water to boiler at minimum cost. Quickly, easily installed, reliable under most severe operating conditions. Ask for Bulletin 513.

4731

PENBERTHY INJECTOR COMPANY

DIVISION OF THE BUFFALO-ECLIPSE CORPORATION

Detroit 2, Michigan

•

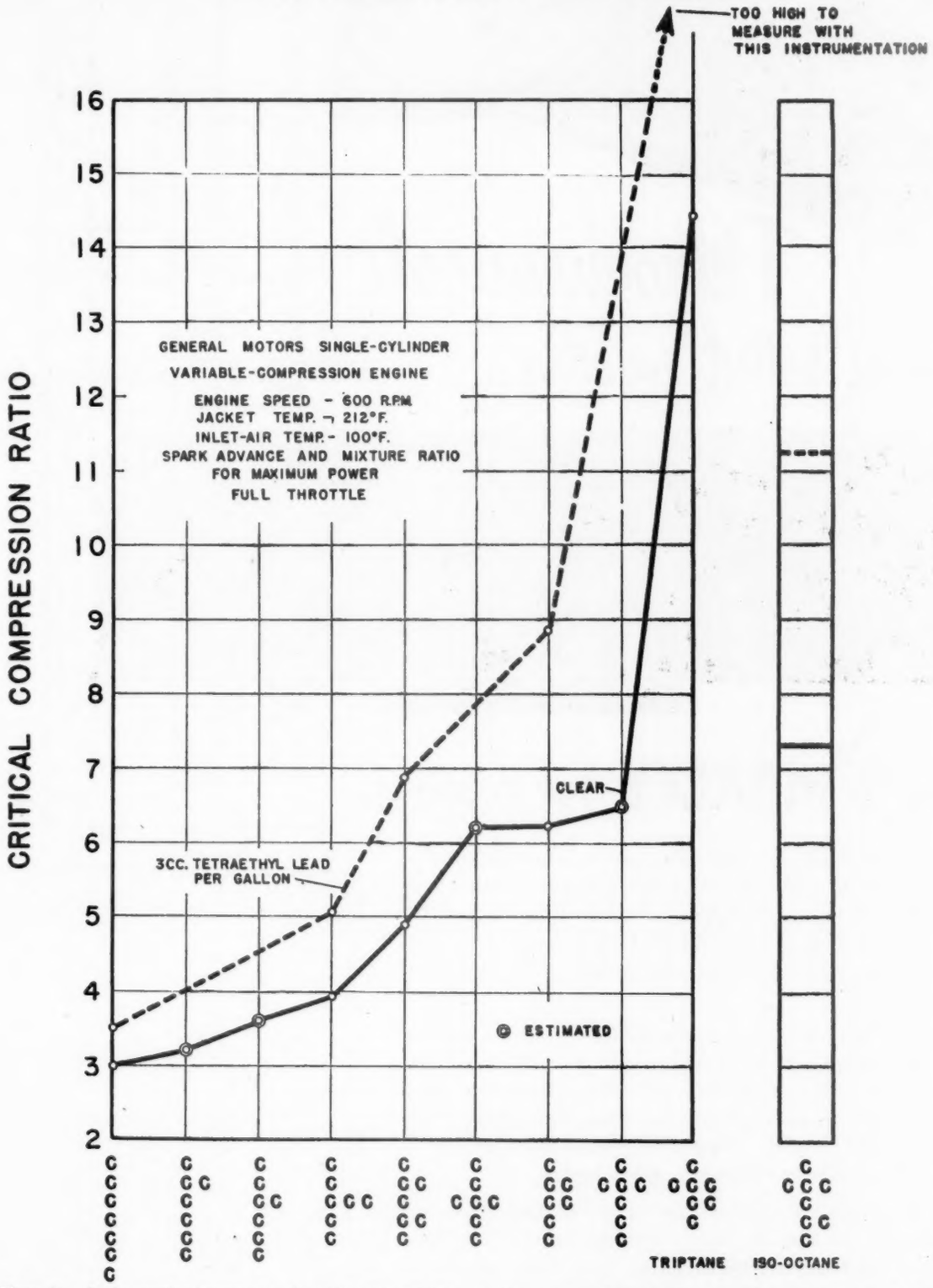
Established 1886

•

Canadian Plant—Windsor, Ontario

EFFECT OF MOLECULAR STRUCTURE OF ENGINE FUELS

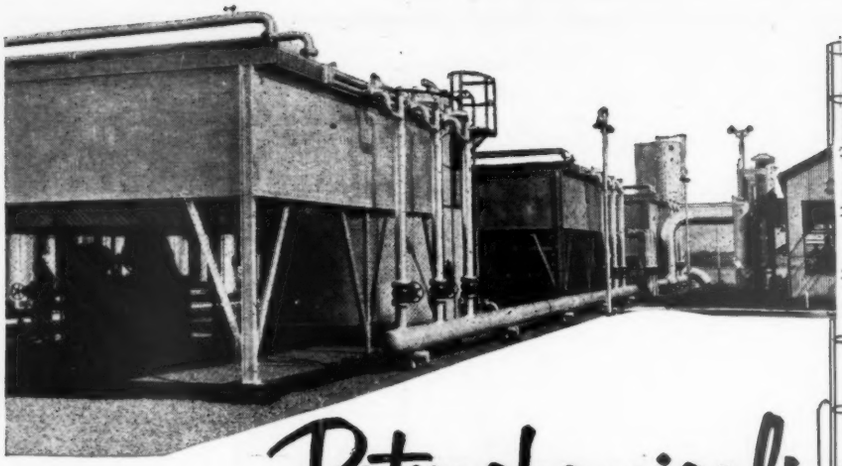
KNOCKING CHARACTERISTICS OF THE HEPTANES



There is a fairly regular increase in the individual critical compression ratios as the structure of the molecule of heptane becomes more closely centralized or highly branched. Referring to the dotted line, the freer from knock the hydrocarbon is of itself, in general, the more effective lead is in making it still better.

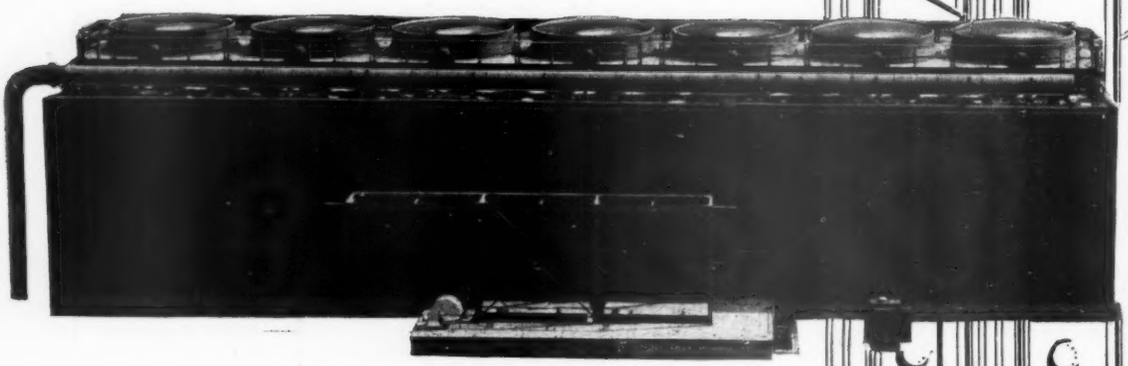
Iso-octane is shown for comparison; note that it is only about half way up on the scale. The great effect of structures is shown in the behavior of 2,2,3-trimethylbutane (triptane), one of the best fuels known as far as knock is concerned.

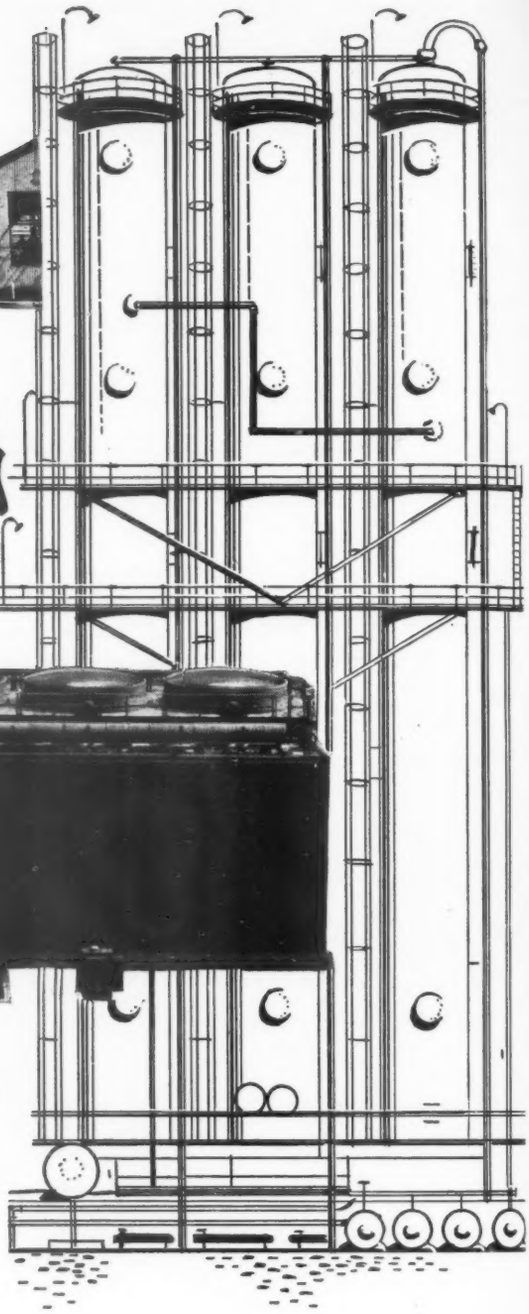
Taken from the paper, "The Effect of Molecular Structure of Fuels on the Power and Efficiency of Internal Combustion Engines," presented by Charles F. Kettering, vice president, General Motors Corporation, before the American Chemical Society in September 1944.



Petrochemicals

Americas "hottest" industry...





..turns to **MARLEY** for cooling

The meteoric rise of petrochemical production marks it as America's "hottest" industry. And keeping pace with petrochemicals, Marley offers the industry the world's most complete line of water cooling towers and DriCooler heat exchangers with everything that is modern in design and mechanical equipment.

Marley cooling towers are a natural choice for plants producing synthetic rubber, synthetic fibers, nitrates, and other base chemicals. They have stood the test of time in the allied fields of petroleum and natural gas with such outstanding success that today Marley cooling towers cool more gallons of water in these industries than any other make.

In Marley's complete line—the only complete line—there's a tower just made to handle your petrochemical cooling problem, whether your cooling method uses cold water or air for heat transfer. Call in the Marley man today for a fair evaluation of your cooling requirement, without cost or obligation.

Producers of
DOUBLE FLOW TOWERS
DRICOOLERS
AQUATOWERS
NATURAL DRAFT TOWERS
CONVENTIONAL TOWERS
SPRAY NOZZLES
DOUBLE FLOW AQUATOWERS

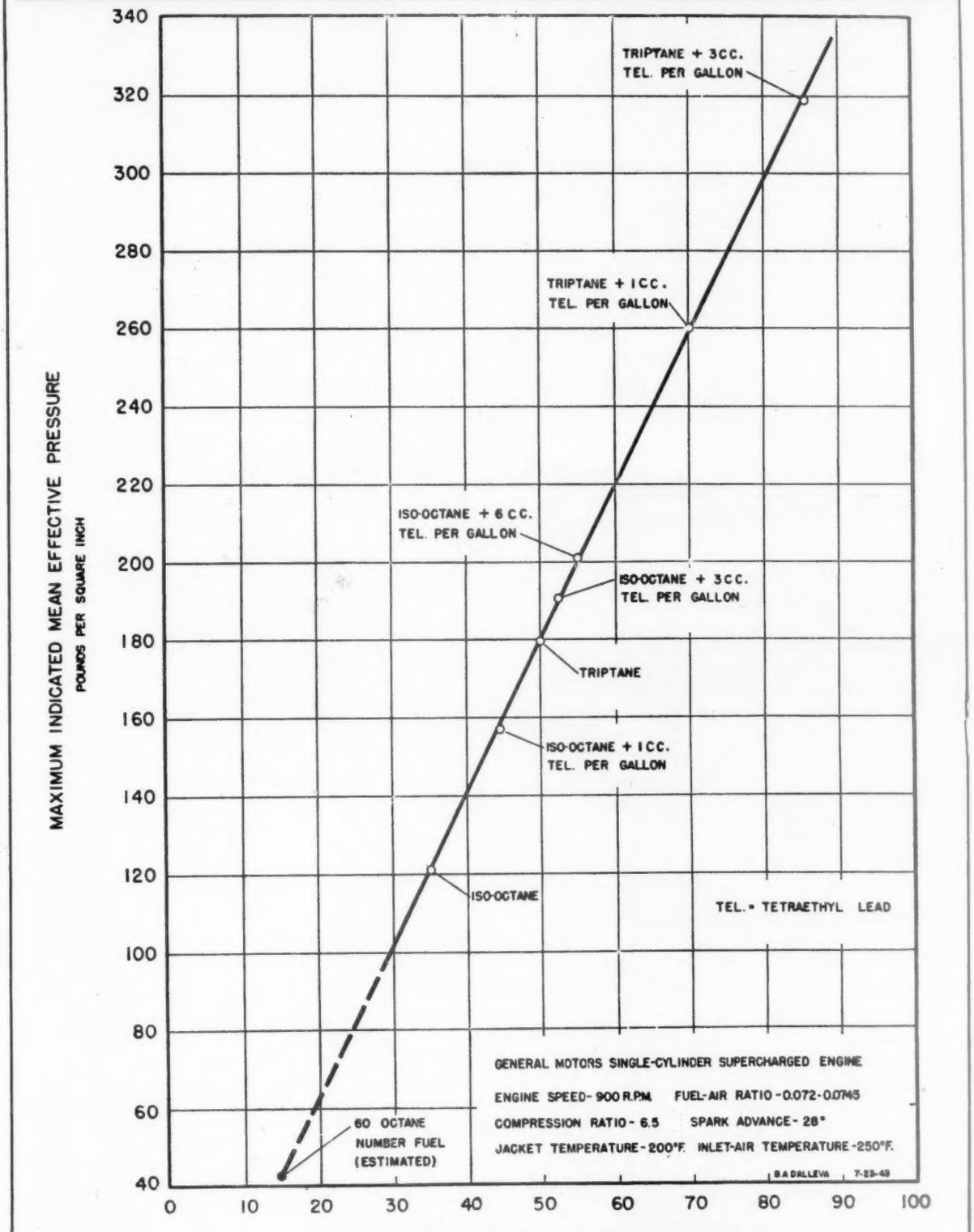
Engineering Sales Offices in 50 Cities

The Marley Company

Kansas City 5, Missouri

MARLEY®

EFFECT OF MOLECULAR STRUCTURE OF ENGINE FUELS



The chart above shows the knock-limited power obtainable from a particular but probably fairly representative supercharged engine with varied amount of supercharge pressure, for several fuels. Here the concern is with the upper range of fuels, and iso-octane of 100-octane number is near the bottom of the chart. The power obtained with leaded triptane is nearly three times as great as with iso-octane.

Taken from the paper, "The Effect of Molecular Structure of Fuels on the Power and Efficiency of Internal Combustion Engines," presented by Charles F. Kettering, vice president, General Motors Corporation, before the American Chemical Society in September 1944.

OIL COUNTRY TUBULAR MATERIAL

油井用鋼管

OEHLFELDROHRE

TUBES POUR L'INDUSTRIE DU PETROLE

MATERIALE TUBOLARE PER I PAESI PETROLIFERI

"OIL COUNTRY TUBULAR MATERIAL" means the same in any language — casing and tubing to carry out world drilling programs and increase oil reserves.

Supply of this vital commodity has been difficult these past several years. Production of API licensed foreign mills has contributed substantially in maintaining the pace which the Oil Industry has achieved against tremendous odds.

Lucey Products Corporation was a key in the organizing and planning necessary to prepare the foreign mills for production of pipe of complete interchangeability . . . strict conformance with API standards of specifications and quality . . . universal acceptance.

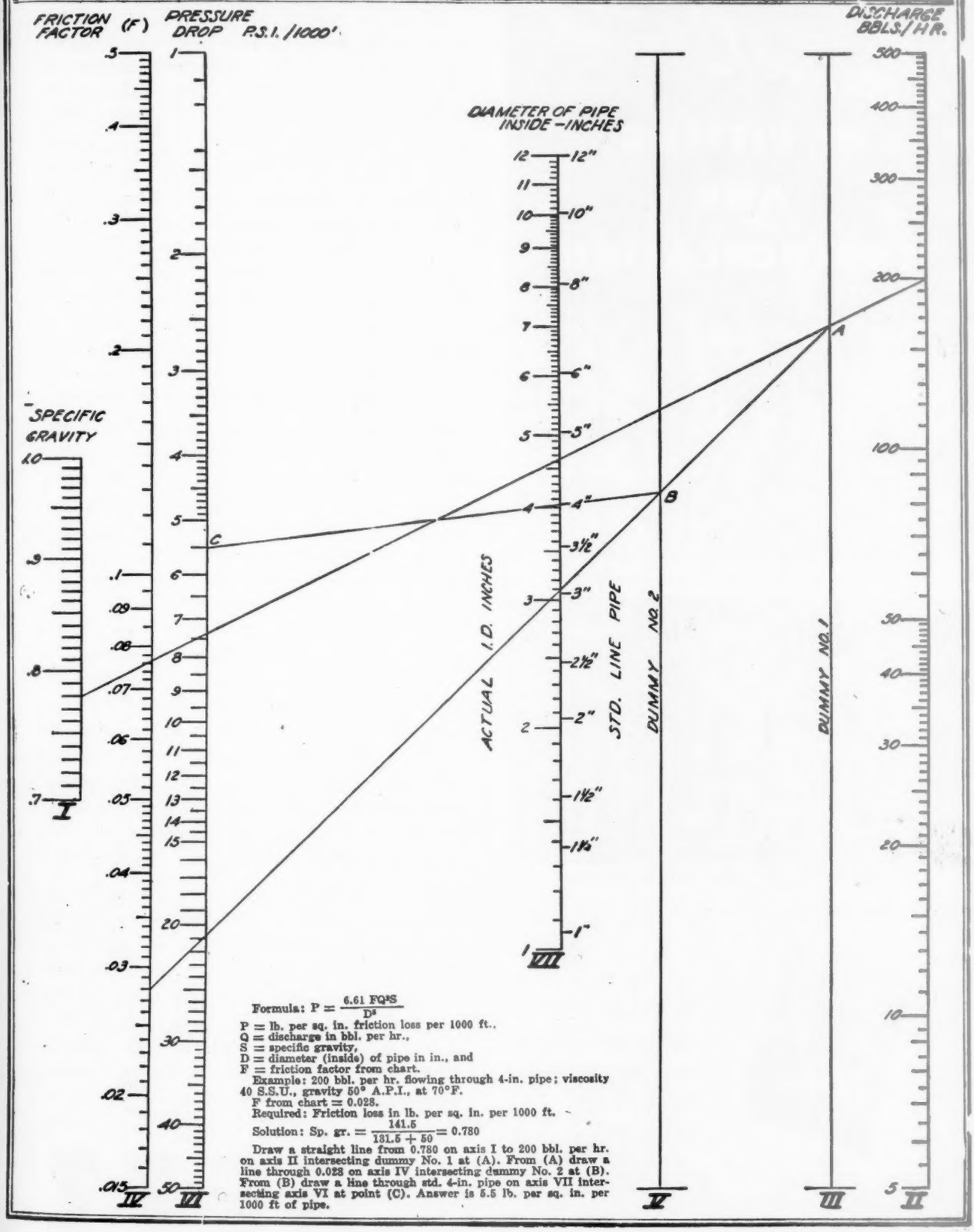
PRODUCTS LUCEY CORPORATION

LUCEY PRODUCTS CORPORATION

OIL WELL SUPPLIES

TULSA, OKLAHOMA

SOLUTION OF FORMULA $P = \frac{6.61\,FQ^2S}{D^5}$ FOR CRUDE OIL FLOW IN PIPE LINES



Formula: $P = \frac{6.61\,FQ^2S}{D^5}$

P = lb. per sq. in. friction loss per 1000 ft.,
Q = discharge in bbl. per hr.,
S = specific gravity,
D = diameter (inside) of pipe in in., and
F = friction factor from chart.

Example: 200 bbl. per hr. flowing through 4-in. pipe; viscosity 40 S.S.U., gravity 50° A.P.I., at 70°F.

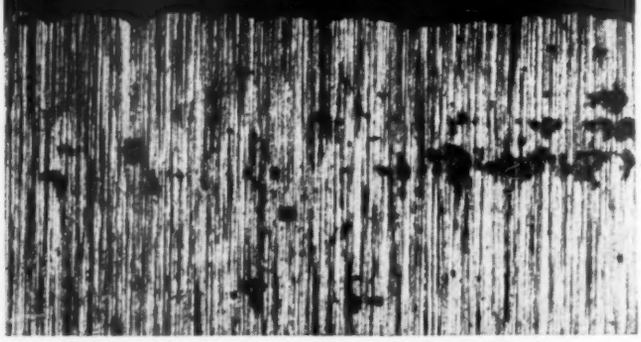
F from chart = 0.028.

Required: Friction loss in lb. per sq. in. per 1000 ft.

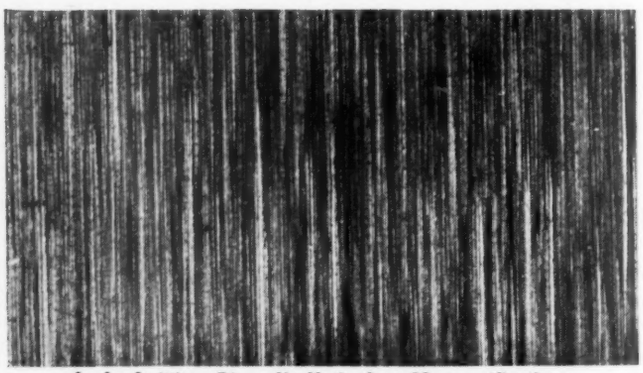
Solution: Sp. gr. $= \frac{141.5}{131.5 + 50} = 0.780$

Draw a straight line from 0.780 on axis I to 200 bbl. per hr. on axis II intersecting dummy No. 1 at (A). From (A) draw a line through 0.028 on axis IV intersecting dummy No. 2 at (B). From (B) draw a line through std. 4-in. pipe on axis VII intersecting axis VI at point (C). Answer is 5.5 lb. per sq. in. per 1000 ft of pipe.

HERE'S *Positive Control* OF PITTING AND TUBERCULATION



Pitting with conventional treatment at 18 magnifications



Lack of pitting, Dianodic Method, at 18 magnifications

A complete report on the Dianodic Method of cooling water treatment. Ask for Technical Paper No. 123.

FOR years, industry has sought a method of chemical treatment that would provide *complete* protection against corrosion, pitting and scale in cooling water systems. Many present day methods for corrosion prevention do effect some decrease in metal loss, but unless excess treatment concentrations are used, localized attack in the form of pitting continues with ultimate metal failure.

Realizing the importance of this major problem, Betz Laboratories has developed the Dianodic Method, an advanced water treatment technique that assures *complete* protection. In this method, the combination of two anodic inhibitors under correct concentration and pH has proved time and again to control pitting and tuberculation, which conventional treatment is unable to control even at much higher concentrations. What's more, the Dianodic Method provides increased protection against general corrosion.

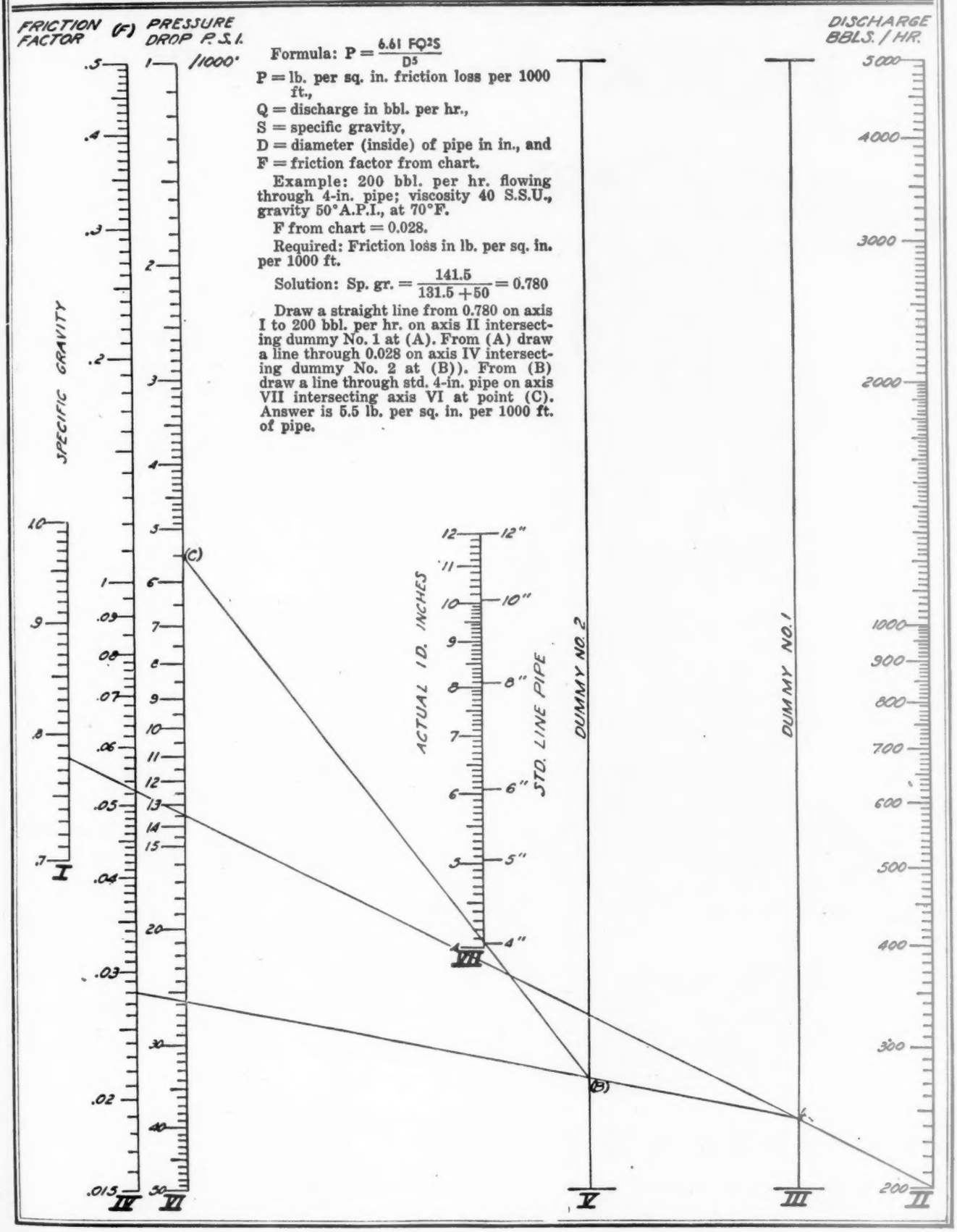
Here's what happened in one refinery which has a circulation rate of 40,000 gpm on its "cat" cracker system. The temperature drop through the tower is 15° F., with closed heat exchangers used for cooling purposes. Inspection of the system after ten months operation with conventional type treatment revealed freedom from scale and general corrosion, but *serious* pitting and tuberculation. Heads of the exchangers were deeply pitted and tubercles were built up to a height of 3 inches. The edges of the end around baffles were severely pitted and required "filling in" by welding. The Betz Dianodic Method was employed and after ten months the results were outstanding. Not only was scale and corrosion controlled, but pitting and tuberculation were eliminated entirely. The welded baffle ends were in perfect condition with the original welding marks clearly visible!

The development and successful field application of this new method of cooling water conditioning is just one example of the outstanding engineering service offered by BETZ. Why not let a Betz Engineer show how you can improve operating efficiency and cut costs in your plant? Write today. W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: Betz Laboratories Limited, Montreal 1.

BETZ

CONSULTANTS ON ALL WATER PROBLEMS

CHART FOR SOLUTION OF FORMULA $P=\frac{6.61\ FQ^2S}{D^5}$ FOR FLOW OF CRUDE OIL IN PIPE LINES



Formula: $P=\frac{6.61\ FQ^2S}{D^5}$

P = lb. per sq. in. friction loss per 1000 ft.,
Q = discharge in bbl. per hr.,
S = specific gravity,
D = diameter (inside) of pipe in in., and
F = friction factor from chart.

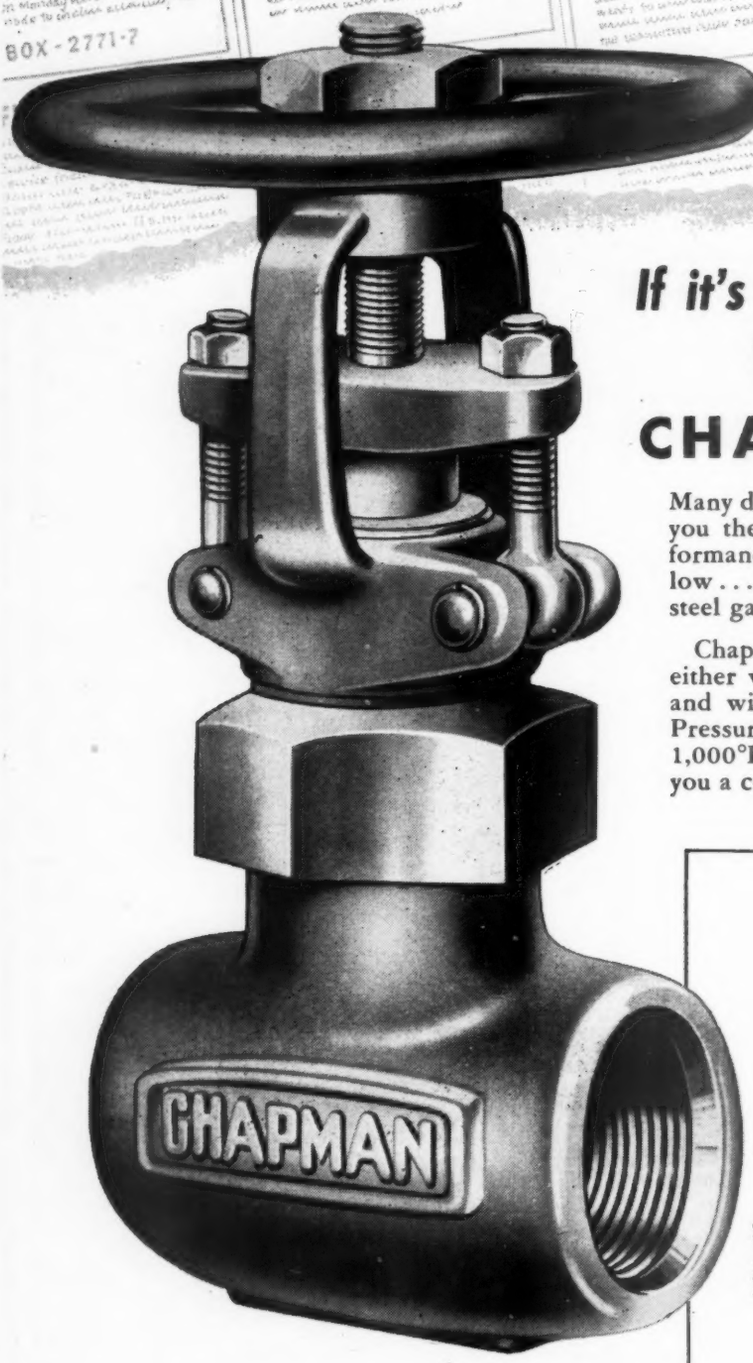
Example: 200 bbl. per hr. flowing through 4-in. pipe; viscosity 40 S.S.U., gravity 50°A.P.I., at 70°F.

F from chart = 0.028.

Required: Friction loss in lb. per sq. in. per 1000 ft.

Solution: Sp. gr. $=\frac{141.5}{131.5+50}=0.780$

Draw a straight line from 0.780 on axis I to 200 bbl. per hr. on axis II intersecting dummy No. 1 at (A). From (A) draw a line through 0.028 on axis IV intersecting dummy No. 2 at (B)). From (B) draw a line through std. 4-in. pipe on axis VII intersecting axis VI at point (C). Answer is 5.5 lb. per sq. in. per 1000 ft. of pipe.

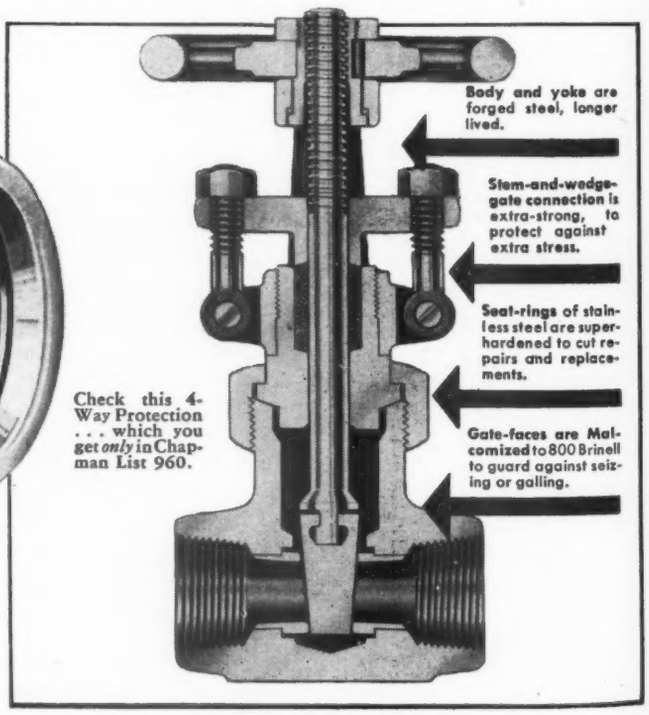


If it's for Small Forged Steel Gate Valves . . . then it's for

CHAPMAN LIST 960

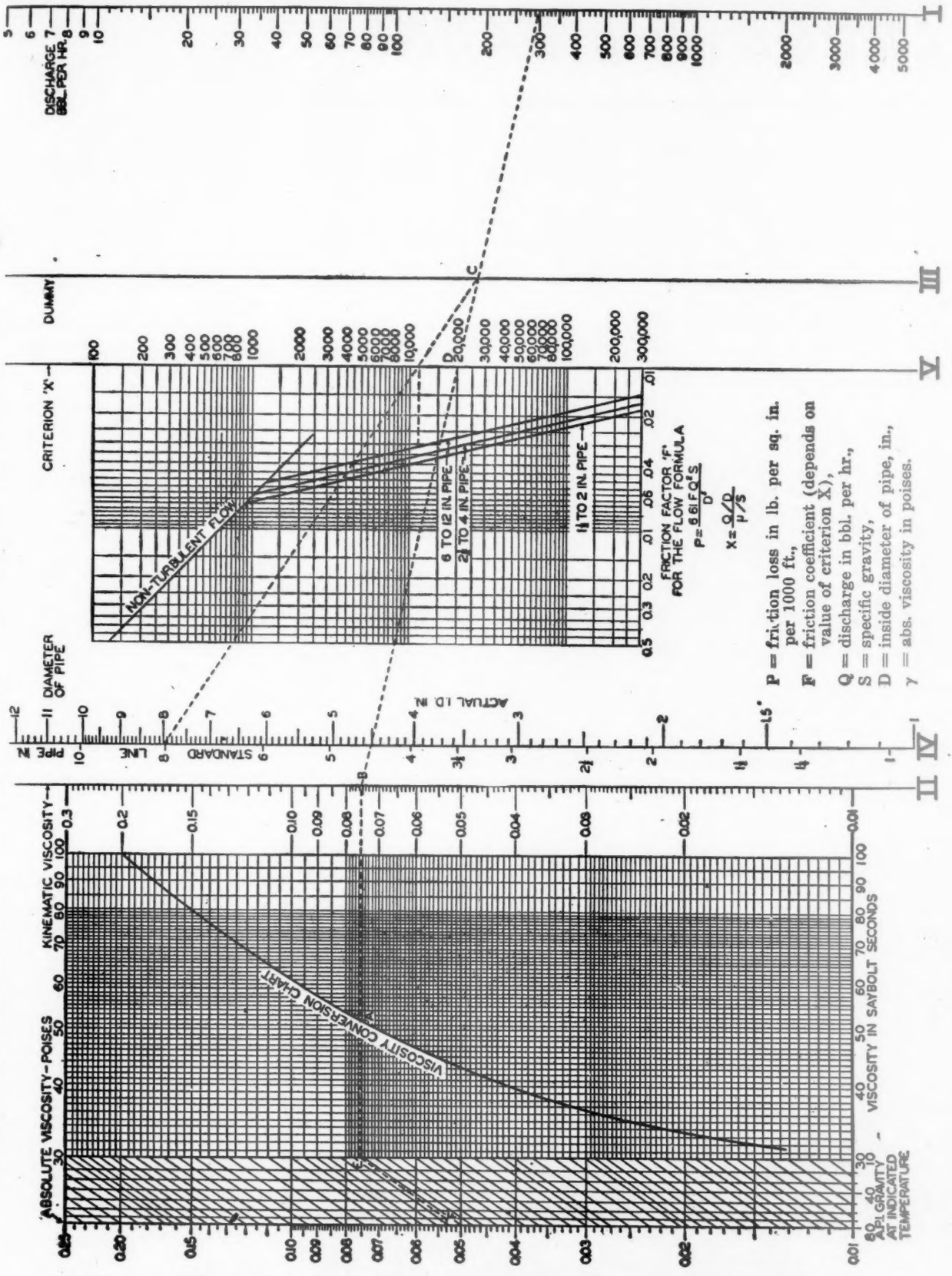
Many different jobs . . . but on each one, List 960 gives you the same top standard of Chapman Valve performance. Check the 4 exclusive Chapman features below . . . and make this your *check list* in buying *all* forged steel gate valves from ½" to 2" inclusive.

Chapman List 960 is manufactured with rising stem, either with yoke as shown, or with inside screw . . . and with gasketed or metal-to-metal bonnet joints. Pressure range: 2,000 lb. at 100°F. to 380 lbs. at 1,000°F. For higher pressures, specify List 990. Have you a copy of Catalog No. 10? Write for it today.


Body and yoke are forged steel, longer lived.
Stem-and-wedge-gate connection is extra-strong, to protect against extra stress.
Seat-rings of stainless steel are superhardened to cut repairs and replacements.
Gate-faces are Malcomized to 800 Brinell to guard against seizing or galling.
Check this 4-Way Protection . . . which you get *only* in Chapman List 960.

The **CHAPMAN VALVE**
MANUFACTURING COMPANY
Indian Orchard, Mass.

CHART FOR DETERMINING THE VALUE OF "F" FOR USE IN THE FORMULA $P = \frac{6.61\ FQ^2S}{D^5}$



EXAMPLE: 300 bbl. per hr. flowing through Std. 8-in. pipe; viscosity 52 S.S.U. specific gravity 70° A.P.I. at 70°F. Find the friction factor F.

Solution: On the viscosity conversion chart draw a vertical line from 52 S.S.U. to point A where it intersects the conversion curve. From A draw a line horizontal to Axis II which it intersects at point B. From B draw a straight line to 300 bbl. per day on Axis I. This line intersects Dummy Axis III at C. From C draw a straight line to 8-in. Std. line pipe on Axis IV. This line intersects Axis V at D. The reading at D is the Criterion X. F can now be determined by use of the chart attached to Axis V. Using the line 6 to 12 in. pipe on the chart and the value of X determined, F is found as 0.031. Under the conditions given it can be seen that turbulent flow will result.

If it is desired to know the absolute viscosity in poises, draw a horizontal line from A to the 10° A.P.I. gravity line, point E. From E draw the line parallel to the diagonal lines to F where it intersects the gravity (70° A.P.I.). From F draw a horizontal line to the left of the chart where the abs. viscosity can be read directly as 0.53.

LAUGH with BARNEY

"Waltz a little faster, dear, they're playing a rhumba."

A drunk fell from a 2-story window and hit the pavement with a terrific impact. A crowd gathered and as the drunk staggered to his feet someone in the crowd grabbed him by the arm asking, "what happened?" To which the drunk replied, "I dunno; I just got here."

The English bride of an American businessman frequently had trouble understanding the United States. Her husband, aware of this, usually went to great trouble explaining things to her in order that she might obtain a better knowledge of her new country. Thus he pictured the position of an important guest they were going to meet at a dinner party: "He works in Washington on price control. Now, for example, take a lamb roast—" and he went on to describe how this man could set the price of lamb roasts all over the nation.

Unfortunately, not being of precise memory, when his wife was presented to the distinguished guest all she could bring to mind of this discourse was something about a roasted sheep. But being an intelligent woman cognizant of the role of modern government in the affairs of men, she put two and two together and said graciously, "You must be the mutton head my husband was telling me about."

Two cockroaches lunched in a dirty sewer, and excitedly discussed the spotless glistening new restaurant in the next block.

"I hear," said one, "that the refrigerators shine like polished silver. The floor sparkles like diamonds. It's so clean."

"Please," said the second cockroach in disgust, "not while I'm eating!"

When a diner complained that he couldn't eat the soup that had been brought him, the waiter called the manager.

"I'm very sorry, sir," said the manager, "I'll call the chef."

When the chef arrived, the diner still insisted that he couldn't eat the soup.

"What's wrong with it?" demanded the chef.

"Nothing," calmly answer the diner, "I just don't have a spoon."

Small son: "I'm not afraid of going to the hospital, mother. I'll be brave and take the medicine, and do everything they ask me to—except I'm not going to let them palm off a baby on me, like you did. What I want is a pup."

Little Audrey, mad as hell
Pushed her sister in the well,
Said her mother, drawing water,
"Gee, it's hard to raise a daughter."

Fellow to blonde at cocktail party: "May I join you?"

Blonde: "Am I coming apart?"

Then there was the couple who had a baby on the first of the month and named him Bill.

Chemist: "I want a preparation of plenylisothiosyanate."

Clerk: "Do you mean mustard oil?"

Chemist: "Yes. I never can think of that name."

McKeon was busily engaged with a spade in the mud beside his car when a stranger hailed him.

"Stuck in the mud?" asked the stranger.

"Oh, no," exclaimed Chester, cheerily, "my motor just died and I'm digging a grave for it."

Judge: "What possible excuse did you fellows have for acquitting that murderer?"

Foreman of Jury: "Insanity."

Judge: "What!?" The whole 12 of you!"

Back in the days of ancient Rome, during the reign of Nero, two dissatisfied Roman citizens met to discuss plans to burn down the city.

"I have heard a rumor that Nero himself plans to set fire to Rome," one of them said. "Why not abandon our plan, and let him do it for us?"

"Why wait for Nero to do it?" replied his companion. "If we do it ourselves, we can eliminate the fiddle man."

"Hello, Jim. Haven't seen you for a long time. Did you marry that beautiful babe you used to go with, or are you still doing your own cooking?"

"Yep."

Drunk: "Ho! Lady you got two ver' beautiful legs."

Girl: "How do you know?"

Drunk: "Because I counted 'em."

A faith healer ran into his old friend Max and asked how things were going.

"Not so good," was the pained reply. "My brother is very sick."

"Your brother isn't sick," contradicted the faith healer, "he only thinks he's sick. Remember that: he only thinks he's sick."

Two months later they met again and the faith healer asked Max, "How's your brother now?"

"Worse," groaned Max, "he thinks he's dead."

At one time laziness was something for comment, but now even automobiles are shiftless.

They asked Aunt Fanny how old she was. "Thirty-nine."

"But that's what you said last year."

"Well, I ain't like some people who'll tell you one thing one time and another thing the next time."

OIL and GAS TRADE NEWS

E. R. Tieberman

M. N. Stickel

J. A. Birkhead

D. R. Davis

W. A. Boles

B. P. Roland

Lunkenheimer Announces New Central District

Establishment of a new central district has been announced by Harold H. Layritz, central division sales manager of The Lunkenheimer Company. The central district, headed by Elmer R. Tieberman, will be divided into five territories. Tieberman will maintain headquarters at Dallas, Texas.

Marshall N. Stickel, with headquarters at Houston, Texas, will have charge of Northeast and Southeast Texas and Southwestern Louisiana. Joseph A. Birkhead will have charge of the Southwestern Texas territory, with headquarters at Houston. D. R. (Dave) Davis will have charge of the Oklahoma, Kansas, and Western Missouri territory, with headquarters at Tulsa, Oklahoma. William A. Boles, with headquarters at Baton Rouge, Louisiana, will direct the Southeastern and Northern Louisiana, Southern Mississippi, and Southwestern Arkansas territory. Byron P. Roland has been appointed representative in charge of the West Texas and New Mexico territory, with headquarters at Midland, Texas.

Pipeline Service Expands

Industrial X-Ray Engineers, has moved to larger quarters at 625 North Rockford, Tulsa, Oklahoma, it was announced by R. R. Hughes, vice president. An affiliate of Industrial X-Ray Engineers, Seattle, Washington, pioneers in the field of weld X-ray, the Tulsa office was opened in 1948.

John W. Watt is field superintendent, Ray D. Flatland is sales and operations supervisor, and B. D. Crawley is shop foreman, at the Tulsa branch.

Ethyl Department Revamped

A realignment of the research, application, and services activities of the research and engineering department of Ethyl Corporation is announced by B. B. Turner, vice president. In place of the five divisions that have been functioning at the company's research laboratories in Detroit, three major divisions will operate under J. B. Mccauley, director of research. Two of these are new. They are the product application division, with Richard K. Scales as director, and the automotive products research division, directed by Wheeler G. Lovell.

Wisconsin Motor Produces 2,000,000th Engine

Wisconsin Motor Corporation's air-cooled engine No. 2,000,000 came off the assembly line and was immediately earmarked for a life of leisure as a "Show Engine" for exhibition at various trade shows throughout the country recently. Again proving that "the first million" is the hardest, 17 years were required to produce the first million Wisconsin air-cooled engines, and only 5 years were needed to turn out the second million. According to officials of the company, present indications point to production of the "third million" within the next four years or less.

Surrounding 2,000,000th Wisconsin air-cooled engine are Peter Zagorski, president, UAW-CIO Local 283; A. F. Milbrath, vice president and chief engineer; A. J. Brown, plant superintendent; E. C. Wurtz, vice president, in charge of manufacturing; Phil Norton, vice president and general sales manager, and H. A. Todd, president, Wisconsin Motor.

Firm Name Changed

Robert J. Barry, who has had his own consulting management engineering firm in Los Angeles for the past seven years, has announced the change in firm name to Barry and Company; and the addition of Theodore M. Barry as a partner. Their offices are at 448 South Hill Street, Los Angeles, California.

Chiksan Organizes New Subsidiary in Canada

Chiksan Company has established a wholly-owned Canadian subsidiary, it has been announced by H. J. Hagn, president. The new subsidiary will operate under the name of Chiksan of Canada Ltd. Over 9 acres of property have been purchased by Chiksan in Brantford, Ontario, and it is planned to construct a plant on this site for the manufacture of Chiksan ball-bearing swivel joints early in 1953. When in operation, Chiksan of Canada will take over the distribution and sale of all Chiksan and Weco products now being handled by Chiksan Export Company in Canada. Officers of Chiksan of Canada Ltd., are: H. J. Hagn, president; Frank Burrill, vice president; G. R. Winder, vice president; and K. K. Knutzen, secretary-treasurer.

Lane-Wells Shop Gets Five-Year Safety Award

Lane-Wells Company electrical shop recently completed five years operations without a single lost-time accident. Presentation of an engraved plaque for "Outstanding Achievement" was made by Rodney S. Durkee, president of the company, to K. E. Shearer, electrical shop superintendent. On hand to aid in the presentation ceremonies were E. A. Miller, works manager, W. S. Keim, Jr., manager of industrial relations, and K. H. Henson, the company's safety engineer.

Hammond Iron Acquires Keyes Tank of Utah, Wyoming

Hammond Iron Works announces the acquisition of Keyes Tank Company of Provo, Utah, and Keyes Tank and Supply Company of Casper, Wyoming. These companies have been licensed to fabricate and sell Hammond designs of conservation storage tanks in the Rocky Mountain area for the last several years.

Present Keyes management and personnel will be retained and operations will be conducted as the Keyes Tank Division of Hammond Iron Works. Lester Johnson with headquarters at Casper is manager of the Keyes Tank Division and the Provo plant is under the supervision of Donald Newell.

Trade News

Hudson-Rush Company Formed

A new manufacturers' representative organization, Hudson-Rush Company, has been formed to handle heat transfer equipment, controls for process indus-

M. A. Hudson

J. W. Rush

tries, and large engine auxiliaries. The firm is a partnership of Morley A. Hudson and Jack W. Rush. Hudson was with Allis-Chalmers and Magnolia Petroleum Company. Rush was with E. I. du Pont, Sunray, and Calumet Refining Company. Prior to their recent association both were division managers with Eggelhof Engineers, Inc.

Rust-Oleum Film Out

Rust-Oleum has announced production of a new full color sound movie, entitled "The Captain's Idea." Subtly weaved into a new version of boy gets girl the film moves through interesting scenes showing new Rust-Oleum ways to stop rust and cut costs in the petroleum and other fields. It includes such highlight features as the new Rust-Oleum roller-coating method, and a special animation section illustrating how Rust-Oleum penetrates rust to bare metal incorporating the rust particles into the coating. For complete information write to Rust-Oleum Corporation, 2425 Oakton Street, Evanston, Illinois.

Posey-Nutto Opens in Casper

W. A. Posey and W. J. Nutto announce the opening of the Posey-Nutto Tool Company in Casper, Wyoming. The company's office and warehouse is under construction adjacent to West Yellowstone Road. W. A. Posey has been tool pusher, a salesman for Reed Roller Bit and district manager for Security Engineering Company, and owned and operated the W. A. Posey Tool Company before the new company was formed. W. J. Nutto was formerly sales manager for the Hunt Tool, Houston.

Pittsburgh Corning Opens District Sales Office

Paul D. Japp, general sales manager of the Pittsburgh Corning Corporation, has announced the opening of a district sales office in Kansas City, Missouri. Howard G. Jones has been appointed district manager of the new office, which is situated in Room 205, Fairfax Building, Kansas City 5, Missouri. Jones was formerly a field representative for Pittsburgh Corning in the Southern Illinois, Kansas and Missouri area.

W. T. Clark, H. R. Conant, Jr., J. P. Dillon, R. L. Perkinson, and R. B. Shofstall will represent the Pittsburgh Corning in Kansas City territory.

Towne Is Dealer for Clark

In line with a world-wide program of expanding and improving its sales and service operations and facilities, the Clark Equipment Company announced the appointment of the Towne Industrial Equipment Company, Inc., of Dallas, as its authorized dealer in Texas.

Cleco Appoints Distributors

The Cleco Division of the Reed Roller Bit Company, Houston, Texas, has announced the appointment of Grant and Company, 2144 E. 7th Street, Los Angeles, California; H. N. Crowder, Jr., Company, 446 Union Street, Allentown, Pennsylvania; and Ponsford Equipment Company, 408 Bassett Tower, El Paso, Texas, as distributors for Cleco products in their areas.

National Supply Expands North Dakota Activities

The National Supply Company has broadened its administrative facilities in its Northwest Division. A. A. Anderson has been appointed division sales manager, with headquarters at Casper, Wyoming, succeeding Robert D. Stottlemyer, recently named assistant division manager.

A. A. Anderson

Two new sales districts have been formed. Walter F. Smith has been appointed district manager of the North Dakota district, covering the Williston Basin area now served by National Supply's Williston and Glendive stores. Charles W. Morris has been named district manager of the Wyoming district, covering the Casper, Cody, and Kevin stores. Robert K. Ford, sales representative at Casper, has been transferred to Denver, Colorado, in the same capacity. Roy E. Bell, sales representative at the company's export division, New York City, has been transferred to Casper. Frank H. Guth, assistant manager, succeeds Smith as manager of the Williston store. J. M. McDaniels, field sales representative at Craig, Colorado, succeeds Morris as store manager at Farmington, New Mexico.

Forms Foreign Subsidiaries

The formation of two wholly-owned subsidiary companies was announced by Gordon Lefebvre, president of The Cooper-Bessemer Corporation. Known as the Cooper-Bessemer International Corporation and Cooper-Bessemer Overseas Corporation, the new companies serve as exclusive export sales distributors for Cooper-Bessemer engines and compressors. Both companies are headed by Michael C. Pollock.

M. C. Pollock

Pipe Line Division of Perrault Sold to Dixon

The pipe line equipment and protection business formerly operated by Perrault Brothers at 1130 North Boston Avenue, in Tulsa, Oklahoma, has been

W. O. Dixon

R. E. Shackelford

purchased by W. O. Dixon, former airplane-parts manufacturer of Wichita and Coffeyville, Kansas. Under the new ownership the business will be known as Perrault Equipment Company. Robert E. Shackelford, who was general manager of Perrault Brothers, has been appointed general manager of Perrault Equipment which is wholly owned by Dixon.

Girdler Builds New Plant

The Girdler Corporation, Louisville, Kentucky, has begun operation of a new plant for the production of activated carbon from hardwood char. The plant includes several new developments that are a part of a continuous process for the manufacture of several types of activated carbon. The continuous process replaces older batch processes and provides means for producing carbon of uniform physical characteristics and high adsorptive capacity.

Atlas Chain Names Agent

Atlas Chain and Manufacturing Company announces the appointment of Barnes and Delaney, Long Beach, California, as an Atlas distributor. Barnes and Delaney will be headquarters for Atlas roller chain and chain parts for the oil field industry in southern California.

Foxboro Expands Facilities

New factory facilities for the assembly of control valves were recently acquired at Dallas, Texas, by The Foxboro Company. Convenient to the office address, 1710 North Akard Street, the new quarters practically double the area devoted to valve assembly and warehousing, and will facilitate rapid delivery and service throughout the South and Southwest.

Caterpillar Plant Nears Completion of Facilities

First steel on a new plant for Caterpillar Tractor Company at York, Pennsylvania, was erected recently. After production begins this year, the facilities covering more than 400,000 sq ft of floor space will enable the company to utilize Eastern steel sources and better supply replacement parts to Eastern and European outlets. The York plant marks an additional expansion for the Peoria, Illinois, firm.

TRADE PERSONALS

R. I. Roth

E. J. Rudisuhle

Robert I. Roth has been appointed vice president in charge of western sales by the White-Roth Machine Corporation. Roth, who will make his headquarters in Dallas, Texas, will be in charge of distributor sales and engineering service for Lorain gas and diesel engines. A sales engineer with the company since his release from the Navy, Roth is a graduate of Case Institute of Technology.

Edwin J. Rudisuhle has joined the sales engineering department of the Lenkurt Electric Company, manufacturers of multi-channel telephone and radio equipment. He will be concerned primarily with the application of carrier channelizing equipment to VHF and microwave radio links. Before joining Lenkurt, Rudisuhle was with the Civil Aeronautics Administration as chief, electronics establishment branch, ninth region.

Earle H. Schlitt, formerly a project engineer for Wolff and Munier, has joined the air conditioning sales department of The Trane Company. He will specialize on the UniTrane and Custom-Air systems for multiroom structures. Schlitt received his mechanical engineering degree from Brooklyn Polytechnic Institute.

Charles N. Bilbey has been appointed manager of the Vernal, Utah, service branch of the McCullough Tool Company. With the company more than five years, Bilbey was field service engineer at Bakersfield, California, until January of 1950, at which time he was transferred to Edmonton, Canada.

Ben "The Flying Dutchman" Mater, export sales engineer of Baker Oil Tools, Inc., touched down long enough to receive his Five-Year award at the recent Baker Service Pin Award Banquet held at the Huntington Hotel in Pasadena, California. For the past five years, Ben has acted as an international trouble shooter for Baker by completing a world-wide trip and several shuttle trips to South America. Most recently he designed and personally supervised the construction of the new, modern Baker Transworld, Inc. Camp in Anaco, Venezuela. Before joining the Baker organization in 1947, Mater worked for the Shell organization in Venezuela.

W. B. Wainwright has been named technical director of the Petroleum Chemicals Department of American Cyanamid Company. Other appointments to new posts include: **V. R. Farlow,** Eastern regional sales manager with headquarters in New York; **E. F. Heizer,** Western regional sales manager with headquarters in Chicago; **T. O. McDonald,** Southern district manager with headquarters in Houston; **Read Larson,** and **Charles O. Brown, Jr.,** sales representatives with headquarters in Chicago.

John Davis has been named representative for Technical Oil Tool Corporation in Southern Oklahoma. Davis will service the area covered by the Continental Supply Company stores at Duncan and Healdton, Oklahoma. Davis replaces **R. K. "Dick" Palmer,** who for the past five years has served the Southern Oklahoma territory for TOTCO.

John Davis

John F. Bishop has been named assistant general manager, instrument division, Beckman Instruments, Inc. Formerly head of special products division, Bishop founded this department for Beckman one and a half years ago. He has contributed many new production and product developments in that capacity, including new computer designs and advanced analytical instruments. He obtained his BS degree at the University of California in 1945 and his MBA, Harvard, 1948.

J. R. Gary

L. H. Christianson

Lee H. Christianson will represent American Iron and Machine Works Company in Canada as a field sales representative and will establish his headquarters at Calgary, Alberta. Before joining the American Iron organization, Christianson spent a year with Halliburton and three years with the Hughes Tool Company in Canada.

Jack R. Gary will represent American Iron in the Gulf Coast area and will specialize in sales of production equipment. Before coming to American Iron, Gary was employed with the Iverson Company and the Guiberson Corporation.

Clifford F. Hood, has been elected president of United States Steel, succeeding **Benjamin F. Fairless,** who will remain as chairman of the board, and chief executive officer of the corporation.

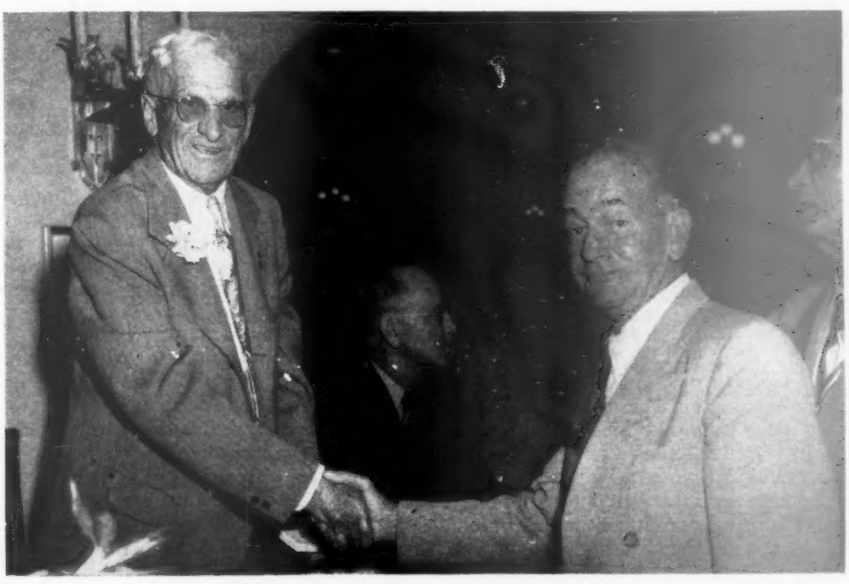
Robert C. Tyson was elected vice chairman of the finance committee and a member of the board of directors and of the finance committee of the corporation, effective immediately. He will also continue as comptroller.

Harvey B. Jordan was elected executive vice president — operations of the corporation.

Walter F. Munford was appointed president of the American Steel and Wire Division of United States Steel.

Howard E. Isham was elected vice president and treasurer of the corporation. He will succeed **Max D. Howell,** who retired from these posts recently.

R. C. Baker, Sr., president and founder of Baker Oil Tools presents 5-year service pin award to Ben Mater at Baker's 11th service pin award banquet.



Trade Personals

J. S. Roscoe has been appointed executive vice president in charge of business administration by the board of directors of The Lincoln Electric Company. **William Irrgang,** who was appointed executive vice president in October 1951, is in charge of all manufacturing. Roscoe has been with Lincoln since 1924 when he was graduated from the Ohio State University.

J. S. Roscoe

Floyd A. Garman has been named chief engineer and **Walter V. Magee,** assistant chief engineer of American Steel and Wire Division, announced by this United States Steel Company division.

Garman succeeds **Harry L. Jenter,** who was promoted to assistant manager of operations of the Cleveland district. Garman attended Mount Union College and Case Institute of Technology earning a degree in mechanical engineering. He began with American Steel and Wire in 1935 as a draftsman. Magee attended Ohio State University where he majored in mechanical engineering. His first job with United States Steel was that of draftsman for National Tube Division in Wheeling, West Virginia, in 1925.

Malcolm P. Murdock has been elected a vice president and director of Ethyl Corporation. The promotions of **Julian J. Frey,** from sales manager, operations, to assistant vice president and of **Harold R. Berg,** from Southern regional manager, to general manager of antiknock sales were also announced.

Murdock assumes the responsibilities for the company's sales activities as the successor to Sanford M. Wagner, who will retire as vice president and director in February.

Berg will be in charge of the sale of antiknock compounds and other additives. He has been manager of the Southern region in Tulsa for the past six years, having joined Ethyl in 1928.

Joseph C. Laley, industrial sales representative for Taylor Instrument Companies previously working out of the Houston office, has been transferred to the Tulsa, Oklahoma, branch where he is covering territory largely south and west of Tulsa. The accounts formerly handled by Laley in the Houston area have been assigned to **Edward M. Davis.** After completing an extensive training course at both Tulsa and Rochester, Davis had experience in customer contact work in the Tulsa territory.

Jay W. Owings, assistant general manager of sales for The Youngstown Sheet and Tube Company for more than three years, has resigned to enter business at Magnolia, Arkansas. Owings joined The Youngstown Sheet and Tube Company's metallurgical department in 1928. He became assistant general manager of sales in 1949.

"Herb" Risner, foreign representative for Fluid Packed Pump Company is on an extensive sales trip to Venezuela and Colombia. He will study "down well" pumping needs in these countries and confer with the National Supply Company of Venezuela, South American distributors for Oilmaster Pumps.

E. W. Hazzard has been appointed corporation export manager of Gar Wood Industries, Inc. In his new position, Hazzard will direct the corporation export operations of Gar Wood Industries and co-ordinate the international sales activities of all Gar Wood divisions.

Herbert E. Brumder has been named general manager of Pressed Steel Tank Company's Downingtown Iron Works Division, Downingtown, Pennsylvania, and **Milton F. Kroesch** as chief engineer of its Milwaukee, Wisconsin, operations. Brumder joined Pressed Steel Tank in 1939, shortly after earning his BS at Yale and has served the company in a number of capacities.

H. E. Brumder

Fred Whittier has been promoted to supervisor of bituminous coatings research and development department, Neville Island, for Pittsburgh Coke and Chemical Company. His previous post had been supervisor of coal tar chemical process improvement in the production department. Whittier joined Pittsburgh Coke and Chemical in 1951.

A. W. McKinney, executive vice president of The National Supply Company, has been elected president of the Diesel Engine Manufacturing Association. The election took place at the annual meeting of the association at the Waldorf-Astoria Hotel, New York City, recently. McKinney joined The National Supply Company, in 1920 shortly after his discharge from the U. S. Army.

A. W. McKinney

Joe M. Rutledge has been appointed assistant export representative in the New York offices of A. V. Simonson, Franks Manufacturing Corporation export manager. Rutledge will have offices at 149 Broadway, New York City.

John M. Tuthill, for nearly three years manager of flat rolled sales, in general offices of The Youngstown Sheet and Tube Company, has been appointed assistant general manager of sales with offices in Chicago.

L. E. Arnold, transferred from the Detroit sales office to general offices early in 1950 as assistant manager of flat rolled sales, succeeds Tuthill.

Allison F. Peters has been named sales manager, Hunt Tool Company. In his new capacity, Peters will be in charge of sales activities for all operations of Hunt Tool Company. He has been in sales work with Hunt Tool for the past 5 years. He was previously a sales engineer with Texas Iron Works in Houston before joining Hunt.

A. F. Peters

Oscar W. Heimberger and **Robert M. Wallace** have been elected vice presidents of The Griscom-Russell Company. Heimberger, who is now vice president — engineering, has been in the company's engineering department since 1923 when he was graduated from Ohio State University. Wallace, who is now vice president—manufacturing, has been with Griscom-Russell since 1928, following his graduation from Brown University.

Richard H. Barton has been named Ethyl Corporation chemical sales representative in the Southeastern states. Barton, who recently joined Ethyl after three years as agricultural chemical sales manager for Innis, Speiden and Company, will make Atlanta, Georgia, his headquarters.

Two intra-company transfers have been made. **Bruce Crane,** who joined Ethyl in 1933, is being assigned a Midwestern chemical sales territory, with headquarters in Chicago. Crane has been an Ethyl field engineer at San Antonio, Texas, for the past seven years.

Paul R. Harris, who has served as Ethyl safety engineer at Seattle since joining the company in 1944, will now be responsible for West Coast chemical sales. He will make San Francisco his headquarters.

C. E. McKim is works manager of National Carbide's new plant at Calvert City, Kentucky, opening the first part of this year. He is former manager of the Louisville plant. McKim joined National Carbide at its Keokuk plant in 1929, and in 1948 became plant superintendent. He was named works manager in Louisville January 1, 1952. **Astor Brown,** who succeeds McKim at Louisville, has been with the company more than 10 yr. He was former works manager at the Ivanhoe plant.

A. T. Erickson has been named executive vice president of Flexitallic Gasket Company. Erickson comes to Flexitallic Gasket Company from Day and Zimmerman, Inc., with whom he was associated as an engineer for approximately 14 yr. During his assignment with Day and Zimmerman, Inc., he has acquired extensive and varied experience in many phases of engineering work. He has served them in various capacities such as chief estimator, superintendent of construction and project engineer. Erickson is a graduate of the Drexel Institute of Technology in Philadelphia.

Robert D. Stottlemyer, division sales manager of The National Supply Company in its Northwest division, has been appointed assistant division manager. He will have his headquarters at Casper, Wyoming. Stottlemyer graduated from the University of Pittsburgh, as a petroleum engineer, in 1941 and then entered the U. S. Army as a second lieutenant. He was then with Gulf Company until he joined The National Supply Company in 1946.

R. D. Stottlemyer

Ernest O. Ohsol has joined Pittsburgh Coke and Chemical Company as director of chemical engineering. Dr. Ohsol will be responsible for economic and engineering evaluations of major chemical projects and will supervise development of process design and specifications. Dr. Ohsol was formerly at General Electric and before that had been with Esso research center of Standard Oil Development Company. He is a graduate of M.I.T.

R. A. Lindsay has been appointed to the staff of technical service and development as heavy industries section manager for The Dow Chemical Company. Lindsay was promoted to the new post from his former position as section head of chemical engineering products, organic chemical sales. Lindsay, who took his MS degree at the University of Michigan joined Dow's consulting engineering division in 1941.

C. H. Erbacher has been named manager of the Morse Chain Company, a Borg-Warner Industry, branch sales office in Detroit 10, Michigan. He formerly handled sales in Chicago, Illinois. **Walter C. Bass** has been named manager of the Ithaca, New York, branch sales offices, and will administer sales of all Morse mechanical power transmission products in N. Y. and Vermont.

John E. Angst, sales agent for the American Car and Foundry Company in Chicago, has been appointed assistant western sales manager. Angst, who will continue to make his headquarters in Chicago, will report directly to John H. VanMoss, western sales manager. He joined ACF in 1945.

J. V. Bond has been appointed sales manager for Tuboscope Company in Louisiana, Arkansas, Mississippi, and Alabama, Tuboscope has announced. His headquarters will be in New Iberia, Louisiana. Bond, who has been with Tuboscope for three years, was a sales engineer before taking new duties.

J. V. Bond

William F. Huggins, president of Le Roi International and Le Roi Pan-American, has been appointed assistant to the president of Westinghouse Air Brake Company. Huggins will perform special assignments directly related to the European companies of Westinghouse Air Brake Company. Huggins was graduated from Gettysburg Academy and Ohio State University, and joined Le Roi in 1945.

Frank Kuether has been named executive engineer, Le Roi Company. Kuether joined Le Roi in 1926 when Le Roi purchased the Beaver Motor Corporation, where he had been employed as a draftsman.

Since then Kuether has been chief draftsman and assistant chief engineer for Le Roi Company.

Bob Scott, Technical Oil Tool Corporation representative, has been moved from Odessa, Texas, to Hobbs, New Mexico, due to the increase in drilling activity in the New Mexico area. Due to the resignation of **Gene McCann, Bud Gibbs** has been assigned to the new Iberia-Lake Charles-Eunice, Louisiana, area. Gibbs was formerly in Odessa. McCann left Totco to enter business for himself.

Bud Gibbs

Bob Scott

Jack Covin has been named manager of the New Orleans, Louisiana, office of Geological Logging Company of Houston. His headquarters will be at 1249 Claiborne Tower. Covin was graduated from Rice Institute in 1929. For the past 10 yr he has been engaged in oil well service work including mud logging.

Jack Covin

Max Hofmann, recently appointed manager of the Waukesha Motor Western, Ltd., organized to transact Waukesha Motor Company sales in Western Hemisphere countries, has been awarded an honorary membership in the Asociacion Mexicana De Importadores De Maquinaria, A. C., the Association of Machinery Importers of Mexico. Fifteen honorary memberships were awarded during a ceremony at the Hotel del Prado. Hofmann was the only non-Mexican among the list of recipients, which included the president of Mexico, four Cabinet Ministers, the Senate leader, and heads of Mexico's leading banking and business institutions.

Ed Dewey has been named supervisor of sales promotion for the Fluor Corporation, Ltd. For six years Dewey has been with Dozier-Eastman and Company, Los Angeles industrial advertising agency, and for the past four years he has been account executive servicing Fluor advertising, merchandising, sales promotion, and a recruiting drive for skilled help in Saudi Arabia. Dewey attended Columbia University in New York City.

Ed Dewey

John C. Tyler is new Southern regional manager, for Insul-mastic. Tyler will be in the company's Houston, Texas, office. From here he will travel throughout the south and the Gulf Coast area. He will provide sales and technical assistance to Insul-Mastic licensees in this territory. During the last year he has been a sales representative for the Industrial Waterproofing Company, the Insul-Mastic licensee in Houston.

Wayne H. Harris, Wilson Supply Company, former store manager at Beaumont, has been transferred to Victoria, Texas, where he is now district manager of the Southwest area. **J. T. Watson** was made manager of the Beaumont store, being transferred from New Iberia, Louisiana. **Gordon Arceneaux,** formerly manager of the store at Lake Charles, was moved to New Iberia. **Jack Collins** was transferred from Houston to Lake Charles as store manager there.

Henry F. Colt, Jr., has been appointed a district manager of Air Reduction Magnolia Company, A Division of Air Reduction Company, Inc. He will make his headquarters at El Paso, Texas, and will have sales responsibility for the El Paso district with offices and plants at El Paso and Hobbs, New Mexico. Colt is a graduate of Harvard University.

Walter Ruckdeschel, managing director of the Gesellschaft fuer Linde's Eismaschinen A. G., Munich, Germany, and an outstanding authority in the field of low temperature separation, has just completed a visit to this country. Ruckdeschel came to this country at the invitation of the Chemical Plant Division of Blaw-Knox Construction Company to discuss recent advances in the field of low temperature separation.

Jackson Kemper has been appointed general manager, Watson-Stillman fittings division, H. K. Porter Company, Inc. Kemper will be responsible for all operating and sales activities of the division, formerly known as the Watson-Stillman distributor products division of which he was sales head.

J. Kemper

Trade Personals

Dr. W. H. Kirkpatrick, formerly chief chemist and plant manager of Visco Products Company, Inc., has been promoted to the office of assistant vice president. Dr. Kirkpatrick attended Iowa

Kirkpatrick

Jacks

Cochran

State College and received his Ph.D in 1935. He joined Visco in July of 1937 as chief chemist and plant manager.

D. M. Jacks has been promoted to the office of assistant vice president of Visco Products. Jacks attended Mississippi State College and Louisiana State University and has been connected with the oil producing industry since 1937, joining Visco Products in October of that year.

Fred E. Cochran, formerly manager of the Mid-Continent Division, was advanced the first of this year to the newly created position of general field manager. His headquarters are in Houston, Texas. He joined Visco in 1946.

T. J. Delaney, has been named public relations director of the Autocar Company, succeeding **Robert F. Wood,** who retired. Wood had been director of public relations for Autocar for 32 years.

Joseph A. Costello, Ethyl vice president, and **Donald K. Ballman,** Dow sales manager, have been named to the board of Ethyl-Dow Chemical Company. **Dr. Graham Edgar,** an Ethyl vice president, and **Dr. E. O. Barstow,** a Dow vice president, retired from the board and elected to replace them, respectively were **B. Bynum Turner,** an Ethyl vice president, and **Calvin A. Campbell,** Dow vice president, secretary and general counsel. Other officers and directors were reelected.

Robert O. Losse, a member of Harnischfeger Corporation since his graduation from the University of Wisconsin in 1937, has been promoted to the position of general manager of the company's truck crane and welder plants in Escanaba, Michigan. Losse recently returned from Dortmund, Germany, where he assisted in the setting up of a new P&H factory for the manufacture of small excavators.

C. Y. Haas has been appointed manager of technical division by Attapulgus Clay Company and has assumed his new duties in the company's laboratories at Camden, New Jersey. Haas holds a Bachelor's degree in chemical engineering from Lehigh University where he graduated in 1938. Haas' successor will be **W. M. Jarnagin.**

C. Y. Haas

Ted C. Schraer, for 14 years manager of the Cincinnati, Ohio, district sales office of The Youngstown Sheet and Tube Company, has been moved to general offices in Youngstown as assistant manager of conduit sales. **C. B. (Ben) Mullender,** a salesman in the Cincinnati office for the last 14 years, succeeds Schraer as manager of the Cincinnati sales office.

Schraer joined The Youngstown Sheet and Tube Company in 1925. Mullender joined Youngstown Sheet and Tube in 1934.

B. A. Cabaniss, formerly district manager of the Sperry-Sun Well Surveying Company, southwest district, has recently been appointed district manager of the Lafayette district office, serving Louisiana and Mississippi. He has spent nine years as sales engineer and district manager with Sperry-Sun Well Surveying Co.

B. A. Cabaniss

Rudolph G. Frank, Taylor Instrument Companies, has established residence in Denver, Colorado, and will cover the territory from Denver to southern Idaho under the jurisdiction of the San Francisco office. Frank is a graduate in mechanical engineering at the University of California.

R. F. V. Stanton

J. F. Bishop

Richard F. V. Stanton was named president of Whitney Chain Company at a recent meeting of stockholders. The new board of directors was also named, and includes several new appointments. Stanton will be active on the board and will serve as the company's chief executive officer. **B. G. Tyrrell,** former controller of the company, was elected treasurer. New appointees to the board of directors are: **Maxwell M. Merritt,** partner in the law firm of Shepherd, Murtha, and Merritt; **Robert E. Carrell,** vice president Arrow-Hart and Hegeman Electric; **Donald S. Sammis,** vice president Underwood Corporation, and **George W. Warnecke,** investment banker in New York City.

James F. Bishop, in addition to his corporate duties of secretary-treasurer, American Hoist and Derrick Company, has been appointed general manager. A veteran of 30 years service with American Hoist, Bishop has been secretary-treasurer since 1945 and a member of the board of directors since 1951. He joined the company in 1923.

Rudy V. Ellis, formerly Louisiana Gulf Coast division manager for the Reed Roller Bit Company, has been transferred to Houston, where he will manage the Texas Gulf Coast sales di-

R. V. Ellis

W. J. Green

vision. He will replace **W. L. Childs, Jr.,** who was recently made sales manager of the oil tool division of Reed. Ellis has been with Reed since 1929.

William J. Green has been appointed manager of the Louisiana Gulf Coast division. This position was made vacant when Ellis was moved to Houston. Green was first employed by Reed Roller Bit in 1940, and since that time has worked in several Reed sales districts.

Frederic H. Holt has been named manager of marketing and **James W. Cooke,** manager of engineering, in the General Electric Company's Control Department.

Holt, a graduate of the Missouri School of Mines, joined General Electric in 1935 as an engineer on the company's test program. In 1950 he was appointed manager of sales—control devices, the position he retained until his recent appointment. Cooke has been with General Electric since 1925 when he joined the test program after graduation from Virginia Polytechnic Institute.

L. W. Cunningham, technical service representative in the Shreveport, Louisiana, area of Oakite Products, Inc., received a special scroll in connection with the company's Distinguished Service Award program from John A. Carter, Oakite president. The program calls for awards to be made annually to the five members of the firm's nationwide field organization adjudged to have rendered especially notable service to industry during the year. Presentation of the scroll to Cunningham was made at a technical-sales conference for Oakite service representatives recently.

Leo M. Brown has been appointed sales manager of St. Paul Hydraulic Hoist. Brown previously served as assistant sales manager at St. Paul Hoist and prior to that was a district manager serving St. Paul distributors in the south central states. Brown succeeds **William F. Keeton** who has resigned to enter business for himself.

L. M. Brown

BOOKS

Introduction to Theoretical Igneous Petrology, *by Ernest E. Wahlstrom. Published by John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y. Price, $6. Pages, 347.*

This book is an attempt to bring together the basic facts and ideas of modern igneous petrology in a form that can be comprehended by the average student of geology. It is assumed that the reader has a working knowledge of petrography and at least an elementary training in physics, chemistry, and mathematics. Brief summaries of modern thought and of papers in the field are discussed, as well as a large number of explanatory line drawings are included. Chapters included are: Crust and interior of the earth; magmas-source of nature; ascent and emplacement of magmas; crystallization of magmas; origin of rock types, and classification of igneous rocks.

Volumetric and Phase Behavior of Oil Field Hydrocarbon Systems, *by M. B. Standing. Published by Reinhold Publishing Company, 330 W. 42nd Street, New York 36, N. Y. Price, $10. Pages, 123.*

This book collects into one volume the widely scattered data on the behavior of hydrocarbon systems in petroleum reservoirs. Hydrocarbon systems have been divided into three categories: gases, condensate systems, and dissolved gas systems. Although primarily concerned with the composition and phase behavior of fluids, the book also discusses the physics of flow of oil and gas in reservoir rock. Measurements made in the laboratory on samples of reservoir fluids and the application of laboratory data to field conditions are fully discussed. Three large charts are separately prepared for day-to-day use.

Annual Report, 1951, Natural Bureau of Standards. *Published by the Bureau, Office of Scientific Publications, Washington 25, D. C. (Misc. Publication 204). Price, $.50. Pages, 105.*

This booklet contains accounts of current activities, as well as more detailed descriptions of especially important scientific developments at the Bureau of Standards, summarizing scientific and engineering investigations conducted by the NBS during the fiscal year, 1951. The scope of research and development is indicated by the names of these divisions: Electricity, optics and meterology, heat and power, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, mineral products, building technology, applied mathematics, electronics, ordnance, and radio propagation.

How to Improve the Utilization of Engineering Manpower. *Published by the National Society of Professional Engineers, 1121 Fifteenth Street, Northwest, Washington 5, D. C. Price, $2. non-members. $1, members. Pages, 52.*

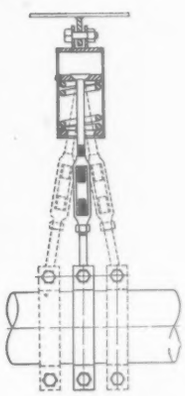
This is a guide book and manual for the executive in companies and organizations employing engineers and engineering services. For the engineer, student, and engineering educator, it is an appraisal and textbook of the values of better utilization. This study pools the experience in utilization of more than 500 leading industrial companies, and engineering organizations, employing some 106,000 engineers and a total of 2,750,000 persons.

Oil Refining and Drilling in the U. S. A., Report by a Group of European Experts. *Published by The Columbia University Press, 2960 Broadway, New York 17, N. Y. Price, $5. Pages, 256.*

A team of eight European oil men was sent to the United States in 1951, representing Austria, the Netherlands, France, Germany, and Italy. It was unlikely that this mission could be expected to make sensational or revolutionary discoveries during its short stay of six weeks in the United States. No attempt is made to describe United States refinery processes and production methods in detail, but rather to comment on these methods in relation to their possible application in Europe. There is an attempt to give an accurate idea of American technique, as a basis for further improvements in the European oil industry.

BLAW-KNOX
FUNCTIONAL HANGERS

Internal swivel action accommodates pipe line movements in ALL DIRECTIONS



The patented Internal Swivel Action, found only in Blaw-Knox Functional Type Spring Hangers, allows *lateral* and *axial* movements within reasonable limits, as well as vertical pipe line movement. This represents a decided improvement over hangers designed for vertical movement only. The pivotal connection within the hanger itself permits the pipe line to move at a considerable angle to the hanger, which is attached to a fixed support.

Because they provide for horizontal movement, Blaw-Knox Functional Hangers help piping engineers solve difficult hanger problems arising from pipe line expansion or contraction, vibration, and pulsations. Catalog No. 51 will give you complete information on Blaw-Knox Pipe Hangers, Vibration Eliminators and Supports—as well as valuable technical data on hanger design. Write for your copy today—no obligation.

BLAW-KNOX CONSTRUCTION COMPANY
Power Piping and Sprinkler Division
Pittsburgh 33, Pennsylvania

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NOTICE: Visco Products Company is authorized to manufacture and sell Visco Oil Treating Compounds for use in the breaking and resolving of oil emulsions, or to grant licenses for such use, under the following United States Letters Patent: 2,060,639; 2,050,640; 2,206,589; 2,214,783; 2,214,784; 2,225,189; 2,303,414; 2,307,813; 2,318,034; 2,318,035; 2,321,056; 2,335,554; 2,454,808; 2,514,399. Visco Products Company is willing to grant licenses on a royalty basis, to oil companies, and to others desiring to practice the patented subject matter, under any and all of the above Letters Patent, permitting the user to purchase the oil treating compounds at will from any vendor, or to prepare the compounds for use or to use the compounds under the above Letters Patent. Application for license should be made to: **Visco Products Company,** Houston, Texas.

New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card

(A) IGNITION IMPROVER

Commercial availability of a new ignition improver for diesel fuels, following a year-long test program with the U. S. Navy, is announced by Ethyl Corporation. Called Ignition Improver (DB-36), the new additive, it is announced, is designed to help refiners produce the desired grades of diesel fuel simply and economically. Blended into the fuel in minute amounts, it increases the tendency of the fuel to ignite. This improvement in ignition quality, which is measured in terms of cetane numbers, is possible with all types of diesel fuels, it is reported.

Circle letter (A) on reply card.

(B) RUBBER HOSE

Republic rubber division of Lee Rubber and Tire Corporation, is now producing a special type of flexible, high-pressure industrial rubber hose called Republic Wiretex. The hose, being manufactured in a newly-completed, multi-million dollar plant, is made with a mandrel cured, Reprene tube in lengths up to and including 60 ft. Republic Wiretex hose is designed to carry various types of gases or fluids under both high and low pressures. The hose is not weakened by constant vibration or flexing and it will not rust or corrode.

Circle letter (B) on reply card.

(C) MICRO-TALKIE

The communications and electronics division of Motorola has announced initial mass production of a hand sized Handie Micro-Talkie transmitter designed to operate in the 152-174 mc frequency band. The compact unit, weighing only 1 lb 13 oz, has a power output of 20 to 40 milliwatts and a tested optimum range up to five miles. The complete transmitter, including self-contained dry batteries and microphone, is contained within a housing.

Circle letter (C) on reply card.

(D) DRAIN GATES

Maintenance Equipment Company has designed and has now available a new P-D fire wall drain gate designed especially for fire wall drains. Featuring a hinged disk with an O-Ring installed around the circumference, the gate provides a positive seal, is easy to open and close, and cannot be damaged or "frozen" by cold temperatures. All contact surfaces are cadmium plated.

Circle letter (D) on reply card.

(E) DUAL STAGE BURNER

The development of a new dual stage burner combining steam and mechanical atomization, was announced recently by the National Airoil Burner Company. Oil entering the burner is first mechanically atomized in an internal swirl chamber. After leaving the mechanical stage, the partially atomized fuel is sprayed into a mixing chamber where it is further atomized by steam.

Circle letter (E) on reply card.

(F) COLOR PIPE

A new yellow plastic pipe that can be easily seen and quickly identified is now being marketed by The Plastex Pipe and Extrusion Company. The exclusive coloring of Plastex yellow pipe has been especially compounded by Plastex engineers for maximum visibility and durability. The color, which goes all the way through the plastic material, will not fade or stain under any conditions.

Circle letter (F) on reply card.

(G) INDUSTRIAL METER

A new 2 BC Rotocycle stainless steel industrial meter has been developed by Rockwell Manufacturing Company to handle corrosive liquids. Based on the patented Rotocycle principle, this new rotary displacement meter features a maximum capacity of 100 gal per minute at a working pressure of 125 psi. All materials in contact with corrosive liquids are of stainless steel.

Circle letter (G) on reply card.

(H) FEED PUMP

%Proportioneers, Inc.%, is exhibiting its newest product the Model 1105-S Adjust-O-Feeder, compact chemical feed pump at the National Exposition of Power and Mechanical Engineering in New York City. The new unit is complete and self contained, weighs less than 100 lb, and is ready to operate as soon as piping and motor are connected.

Circle letter (H) on reply card.

(I) GREASING UNIT

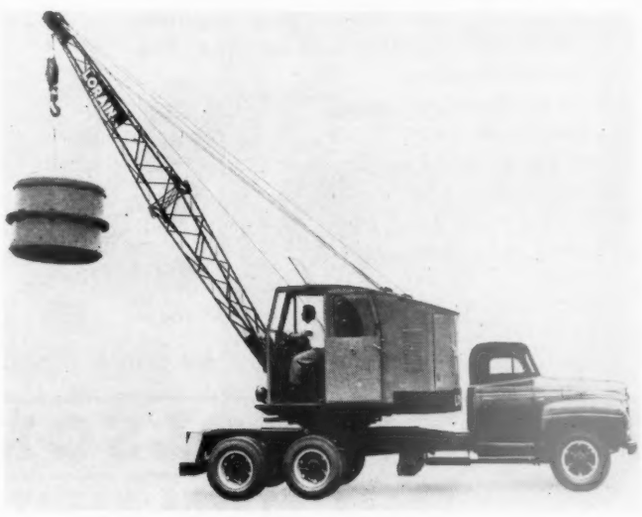
G and T Industries has placed a new portable high-pressure greasing unit on the market. The 6-V Greasemaster, as it is called obtains its power from conventional 6 or 12-v vehicle batteries and weighing less than 40 lb, the Greasemaster has opened new fields in greasing with heavy equipment operators. Its manufacturers say that this gun cuts down greasing time considerably.

Circle letter (I) on reply card.

(J) TRUCK CRANE

The Thew Shovel Company announces the addition of a new 6-ton truck crane to their line of products. It is designated as Lorain Model TL-10 truck crane. The Lorain TL-10 crane consists of a complete superstructure equipped as lifting crane that can also be used as a $\frac{3}{8}$ yd dragline or clamshell. It is designed primarily for field mounting on a suitable new or used truck provided by the customer. The Lorain TL-10 is a two drum, gasoline-powered machine.

Circle letter (J) on reply card.



Thew Shovel Company's newest addition to their line of product is a 6-ton truck crane, called the Lorain Model TL-10 truck crane. It is fully equipped with a 25 ft 2 piece butt flange connected boom.

New Equipment

(K) CONSOLIDATED RIG

National Supply Company has introduced a new rig, the Ideal Type 55 consolidated rig, now in operation in California. The drawworks is mounted on a 9-ft substructure at the foot of a 133-ft derrick. The entire surrounding layout, including pipe racks and mud facilities, was planned for efficient operation.

Circle letter (K) on reply card.

(L) DIESEL ENGINES

Detroit Diesel Engine Division of General Motors has announced two new diesel engines for offshore and coastal oil well drillers and another of interest to both offshore and inland drillers. Two marine diesel engines are especially adaptable for use as propulsion engines in crew boats. One is an 87-hp marine propulsion engine designed for small craft and the other is 130 hp, and an adaptation of series "171" engine.

Circle letter (L) on reply card.

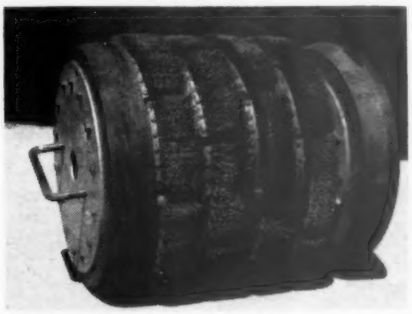
(M) TEST METER

A new portable multi-range voltmeter and milliammeter, providing in one compact instrument the means for making all the electrical measurement necessary to install and service two-way radio communications systems, was announced by the engineering products department of the RCA Victor Division, Radio Corporation of America.

Circle letter (M) on reply card.

(N) PIPE LINE PIG

Cleaner Pipelines Company has announced development of a new spring loaded pipe line pig. A heavy, individual coil spring under each brush forces



brush outward against pipe wall, compensating for all brush wear. A 24-in. cleaner has 32 separate brush segments with coil spring under each brush. There are nearly 1000 sq in. of brush area.

Circle letter (N) on reply card.

(O) STEAM GAGE

A new illuminator for steam gages, the Jerguson mercury vapor illuminator, announced by Jerguson Gage and Valve Company permits instant and accurate gage readings of the boiler water level over longer distances, it is reported. When a gage is equipped with a Jerguson mercury vapor illuminator, the water column shows blue-green, topped with an intensely brilliant emerald green spot.

Circle letter (O) on reply card.

(P) HEAVY CRANKSHAFT

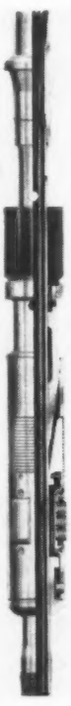
Deep hole drilling in heavy crankshafts is done with a special horizontal machine built by The Cooper-Bessemer Corporation for its own use at Grove City, Pennsylvania. The machine head moves along the shaft, swivels to any angle, and adjusts vertically to any required height so that a complete shaft can be drilled at a single setting for drilling deep oil holes on heavy crankshafts. This crankshaft weighs nine tons, and is the type for GMW 10-cylinder gas compressor engine.

Circle letter (P) on reply card.

(Q) PIPE LINE FELT

Air and gases cannot be trapped and form blisters under a new pipe line felt developed by The Ruberoid Company, the manufacturers claim. Ruberoid perforated pipe line felt forms a bond every time because tiny pin pricks permit gases and surface moisture to escape easily during the wrapping operation. Small perforations are spaced to maintain the normal tensile strength of Ruberoid felt and give it greater flexibility. After wrapping, minute quantities of hot enamel fill the voids.

Circle letter (Q) on reply card.



(R) PACKER

A new packer that is said to eliminate the common causes of packer failures at four critical steps has been developed by Oil Center Tool Company. Slightly smaller in diameter than most packers, the new packer runs in without difficulty and goes right through tight spots. Large fluid bypass areas permit fast running and premature setting is eliminated by the automatic clutch. Rugged construction prevents damage when running through tight places or foreign matter. Left hand rotation is not required in setting the packer.

Circle letter (R) on reply card.

(S) PANEL INSTRUMENTS

Weston Electrical Instrument Corporation announces full qualification approval by U. S. Signal Corps of the newly designed Weston ruggedized panel instruments, (Model 1521 class 52, microamperes through 8 milliamperes d-c inclusive,) under specification MIL-M-10304. No approvals had previously been granted under these rigid specifications. The test specifications set up by the Signal Corps for these instruments call for specific shock, vibration, bounce, thermal and humidity cycling, and immersion tests.

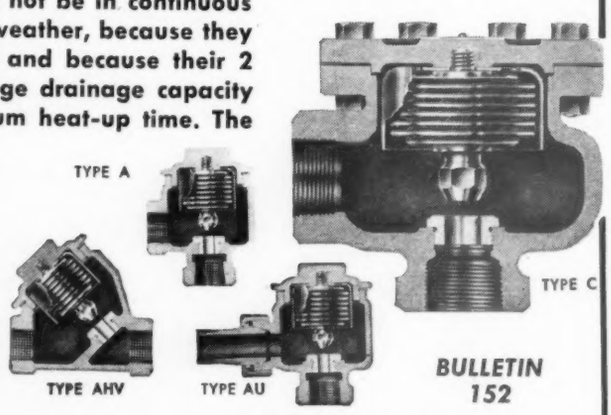
Circle letter (S) on reply card.

NICHOLSON MAKES

Freeze-Proof Steam Traps

for Every Plant Use

Because they drain completely when cold, these four types of Nicholson steam traps are positively freeze-proof. Can be freely installed outdoors. Universally recommended for use in lines which need not be in continuous use during cold weather, because they are freeze-proof and because their 2 to 6 times average drainage capacity results in minimum heat-up time. The non-air-binding feature of Nicholson traps also notably facilitates heat transfer in severe weather. Sizes ¼" to 2"; pressures to 250 lbs.



BULLETIN 152

217 OREGON ST., WILKES-BARRE, PA.

W. H. NICHOLSON & CO.

TRAPS · VALVES · FLOATS

(T) HEATING CENTRIFUGE

The L-K Pump Valve Company is now manufacturing and can make deliveries of a new 115-volt a-c electric heating centrifuge. It was developed to meet the need of the petroleum industry for a centrifuge that will keep oil samples at specified API and ASTM temperatures during the whirling period for true impurity tests.

Circle letter (T) on reply card.

(U) MOTOR CONTROLS

Crouse-Hinds Company has incorporated new improvements in its type EPC explosion-proof line starter and circuit breaker Condulets. The new design is known as Model M52. In addition to its original advantages of threaded joint construction throughout, following new features have been added:

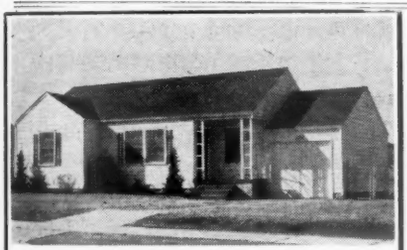
Built-in pushbutton stations and selector switches, additional back conduit entrance and, horizontal through-feed conduit entrances, and others.

Circle letter (U) on reply card.

(V) ARBOR PRESS

A new bench type arbor press has been developed by Manzel having a wide range of uses. Design tested, the 10-ton press is now in production. Press is widely usable in tool room, laboratory, or machinery overhaul department, for such applications as straightening, material testing, bending, bushing, or bearing removal and replacement, etc.

Circle letter (V) on reply card.



Find out about America's finest Field Home —

The Whitmor distinctive field home is outstanding because of the variety of designs, the method of site fabrication that gives you a conventionally built house, at no extra cost. If you prefer, you can have Whitmor homes on a lease-rental plan (Write for complete descriptive illustrated brochure about Whitmor field housing).

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ADDRESS.....
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STATE.....

(W) PIPE

A new high strength Fibreglas pipe, to be marketed under the trade name of Bettis "Spiral-Glas" is now available from Bettis Corporation. The greater strength of Bettis "Spiral-Glas" pipe is obtained by a manufacturing process, in which continuous strands of Fibreglas are wrapped under tension in opposing spirals around a mandrel, with additional layers of Fibreglas strands equally spaced around the circumference, but running parallel with the axis to obtain high tensile strength.

Circle letter (W) on reply card.

(X) SWING JOINTS

Introduction of an extensive new line of ball bearing equipped swing joints for use on loading and unloading lines handling oil, gasoline, chemicals, and other liquids is announced by Barco Manufacturing Company. The design is distinguished by a long lubricated bearing that provides adequate support for piping and a new method of positioning the ball bearings, which prevents them from falling out when the joint is taken apart. Sealing is by means of an "O" ring confined in a recess in the sleeve of the joint.

Circle letter (X) on reply card.

(Y) SAND LINE CUTTER

The new Kinley sand line cutter developed by M. M. Kinley Company, cuts stuck line inside casing. This tool is now ready for use inside 5, 5½, and 7-in. casing. It can be used with slight modification to cut stuck sand line inside tubing as well. The tool rides the line into the hole. A go-devil is then dropped onto it, setting off a charge which cuts the line and crimps it for removal of the cut line and tool. This new sand line cutter is simple and dependable in operation, the manufacturer reports, and is based on the same principle already in use by the Kinley sand line cutter for tubing.

If for any reason the cutter is not recovered on the end of the cut line, Kinley reports, the tool has been designed for easy fishing.

Circle letter (Y) on reply card.

(Z) VACUUM CONNECTORS

Central Scientific Company announces a new line of precision-built connectors for joining tubular elements in vacuum systems. Type CHV is for making a vacuum-tight metal-to-glass connection and is especially useful for making a leak-proof seal with the glass stem of a thermocouple, Pirani, ionization, or other type vacuum gage. Type CHV is hand-tightened, requiring no special wrench, and permits rapid connection or disconnection of vacuum systems. The "O" ring, which compresses to make the positive seal, is of special composition suitable for high vacuum use and temperatures to 200 F.

Circle letter (Z) on reply card.

(AA) CARBIDE BALL

Kennametal Inc. has developed a new lightweight carbide ball for use in the oil industry. It is one-third lighter than steel, and about one-half lighter than tungsten-carbide, the manufacturers claim. Called Kentanium, the new ball has a specific gravity of 6.15. On gas locked conditions where oils with high gas ratios are being pumped and the gas anchor capacities are insufficient to eliminate blow-by through the standing valve and pump entry, the lightness of the ball is again a big advantage in shock relief. In pumping low-head fluids where fluid levels are below the gas anchor entry of the standing valve, lightness provides greater sensitivity.

Circle letter (AA) on reply card.

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FISHING TOOL CO.
GREAT BEND, KANSAS
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Trade Literature

Publication will be sent free.

(AB) ELECTRIC POWER

A new 20-page bulletin on equipment for the generation, transmission, distribution, and utilization of electric power in oil field and pipe line applications has been announced as available from the General Electric Company. Designated as GEC-926, the bulletin briefly discusses operational problems of deep-well drilling and oil-well and pipe-line pumping.

Circle letter (AB) on reply card.

(AC) GATE VALVE

A new brochure fully illustrated has been published by McEvoy Company describing its new automatic self-sealing conduit gate valve. The automatic self-sealing system of this valve can best be described as a sealing compound feeding system that operates while the valve is closed. To facilitate understanding of the McEvoy valve, the folder has been so constructed as to allow the reader to move the gate, containing the jumper, to either the open or closed position. McEvoy claims that its valve actually stops leaks as they start.

Circle letter (AC) on reply card.

(AD) LUBRICANTS

The Texas Company has announced that the December issue of "Lubrication" is available to the public. This issue contains an article titled "Lubricants—1902-52," fifteen pages of the history of lubricants. The article is illustrated with figures and diagrams, and subject matter thoroughly covered.

Circle letter (AD) on reply card.

(AE) OIL WELL ACIDIZING

BJ Service, Inc., has published a 4-page brochure describing its oil well acidizing service. Copy is divided into 4 parts giving the manufacturers' reasons for the high type service given by BJ Service. The leaflet describes materials used by the company, experienced personnel, equipment, and availability of the service.

Circle letter (AE) on reply card.

(AF) SEPARATORS

A colorful new 8-page bulletin has just been published dealing with the Southwestern Engineering Company separator. Southwestern Engineering of California has successfully developed versatile mechanism for wet or dry screening—from 20 to 325 mesh screens. One of the main features of the new SWECO separator is its great production capacity at amazingly low operating costs.

Circle letter (AF) on reply card.

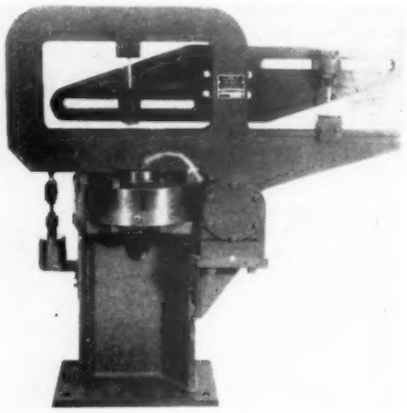
(AG) PACKER

Oil Center Tool Company has issued a manual describing its new all-purpose packer which successfully eliminates the four major causes of packer failures. The booklet contains descriptive material on the three models of packers with setting tables, price lists, and diagrams.

Circle letter (AG) on reply card.

(AH) MEASURING DEVICE

Link Engineering Company has announced a 4-page leaflet describing a new dynamometer torque measuring device developed by the company. Attached picture shows a high load Uni-Beam capable of measuring torque loads up to 6000 lb-ft and in both directions of rotation. Uni-Beams are calibrated by adjustment of the cable assemblies. The indicating device can be remotely located to the most convenient location.



Circle letter (AH) on reply card.

(AI) CHEMICAL PROCESSING

A new catalog of products for use in the chemical processing industries has just been issued by the mechanical goods division of United States Rubber Company. Process industries such as chemical, petroleum refining, tank and pipe linings, hose, pinch valves, etc., are listed in the booklet. Chemical properties, temperature limitations, sizes, and recommended working pressures are covered in the new catalog.

Circle letter (AI) on reply card.

(AJ) PRESSURE SWITCH

A new piston type multi-range pressure switch has been placed on the market by the Bobrick Manufacturing Corporation. Designed to overcome the inherent weaknesses of the Bourdon tube and diaphragm type of switches, it is claimed that the new Bobrick 600 series pressure switch will operate satisfactorily between –65 F and 250 F and that its caliberations are not affected by acceleration, shock, vibration, etc.

Circle letter (AJ) on reply card.

(AK) PIPE MAKING

A new catalog has just been issued by the Southern Pipe and Casing Company. This new, 42-page catalog contains much information on the many interesting steps in pipe making, as well as the latest procedures in the applications of various protective coatings. Occasion for the issuance of the new catalog is the company's celebration of its 20th anniversary.

Circle letter (AK) on reply card.

(AL) TWO-WAY RADIO

A new 8-page illustrated booklet, published by General Electric Company, discusses the use of two-way radio for better coordination of men, materials and machines. The booklet is titled "Instant Communication." It outlines the use of two-way radio in numerous industries, and shows G-E equipment now available for a wide variety of applications.

Circle letter (AL) on reply card.

(AM) TRENCHER

A new bulletin fully describing the Cleveland Model 95 trencher has been published by the Cleveland Trencher Company. The Model 95 is the standard machine for city and suburban work. Copy stresses job applications and outstanding features. Center-spread of the 8-page, 2-color bulletin is a detailed study of Cleveland design, materials, and construction. Complete information is provided on component parts—from the powerful 320 cu in. engine to the rooter tips on the buckets. A numbered outline photograph positions important parts.

Circle letter (AM) on reply card.

(AN) OIL FIELD EMULSIONS

The use of steam for treating oil field emulsions is covered in an eight-page bulletin just released by Stentz Equipment Company. This treating method has many advantages where corrosion is a problem, and flexibility in operation is required. Design information, as well as typical installation data, for steam treating units are also included.

Circle letter (AN) on reply card.

(AO) PUMPING UNIT

Just produced by the Pelton Water Wheel Company is a brand new colored brochure featuring long stroke hydraulic pumping units. This is the most comprehensive treatise on the subject of long stroke hydraulic pumping written to date. The complete story from theory to practice is presented in a well organized and well illustrated text.

Circle letter (AO) on reply card.

(AP) MIXER

A six-page bulletin on the Shortstir side entering mixer, a fluid agitator for use in pipe line, refinery, and process operation, has been prepared by the Sawyer-Jensen-Ross Company. This bulletin contains dimensional diagrams and drawings and large air-brushed scale drawing of the mixer, showing integral gears, etc.

Circle letter (AP) on reply card.

(AQ) ENGINEERING SERVICE

Badger Manufacturing Company recently issued an illustrated brochure giving a brief outline of the experience and background of its engineering personnel, and describing the services it is now in a position to offer.

Circle letter (AQ) on reply card.

(AR) PIPE LINE INSTRUMENTATION

Three new engineering data sheets, describing advanced instrument applications in gas distribution, have just been issued by The Foxboro Company, makers of industrial instruments for measurement and control. Available on request are: AED 783-15, Limiting Flow Control; AED 783-16, Pressure Compensating Limiting Flow Controller; and AED 783-17, Auto-Selector Controller for Limiting Natural Gas Flow and Pressure.

Circle letter (AR) on reply card.

(AS) GUIDEBOOK

Pittsburgh in 1795, when Fort Pitt stood guard at this "Gateway to the West," is contrasted with the city of the future in maps included in a booklet prepared by The National Supply Company. Distributed to visitors to National's new general offices, in Pittsburgh's Gateway Center development, the 12-page booklet gives a brief account of the city's history, as well as information about the company. A four page insert includes a map of present day Pittsburgh.

Circle letter (AS) on reply card.

(AT) ELECTROFORMING

The International Nickel Company, Inc., has published a four-page reprint titled "Electroforming Difficult Shapes." The bulletin gives details of 12 applications that suggest other possibilities in joining, eliminating costly machining, making complex accurate shapes, forming dies, bonding abrasives, reproducing detail and making continuous fine mesh screens. Advantages are shown to apply to many diverse extremes.

Circle letter (AT) on reply card.

(AU) 1953 CATALOG

The McCullough Tool Company has just issued a new 40-page illustrated general catalog. This 1953 catalog contains a complete description of the entire line of specialized tools and services available to the oil industry through the McCullough Tool Company. It gives an explanation of the sizes, applications, and operations of numerous tools.

Circle letter (AU) on reply card.

(AV) DIESEL ENGINE

A new bulletin on the TS diesel engine has been published recently by Ingersoll-Rand. This 12-page, 3-color catalog incorporates sectional wash drawings, installation views, and diagrams to show why the TS diesel is called a smaller, lighter, but fully heavy-duty engine. It is a 7 by 8½ in., 900 to 1000 rpm in the 200 to 400 hp class.

Circle letter (AV) on reply card.

(AW) PRECISION INSTRUMENTS

Minneapolis-Honeywell Regulator Company has announced its new Catalog containing factual information concerning ElectroniK non-control precision instruments, which employ a potentiometer, Wheatstone bridge, or other measuring circuit to measure temperature, pressure, and other variables. The literature presents detailed specifications for each particular model. Also included is information on specially adapted ElectroniK instruments.

Circle letter (AW) on reply card.

(AX) OIL FIELD EQUIPMENT

A wide variety of equipment used in the oil fields, including chain, sprockets, bearings, shale shakers, and shovel-cranes, is described in a new 36-page Book No. 2480, published by Link-Belt Company. Illustrations, tables of weights, strengths, and dimensions, and other pertinent engineering information facilitate correct selection of equipment.

Circle letter (AX) on reply card.

(AY) ORGANIC CHEMICALS

The 1953 edition of the booklet, "Physical Properties of Synthetic Organic Chemicals," has just been issued by Carbide and Carbon Chemicals Company, a Division of Union Carbide Corporation. This 20-page booklet is issued annually. This year for the first time the booklet includes a section on 56 new research chemicals available from Carbide and Carbon. The new edition presents data on more than 320 products.

Circle letter (AY) on reply card.

(AZ) GROMMET V-BELT

The "Texrope" grommet v-belt, for which 20 to 50 per cent longer life is claimed, is described in a new bulletin released by Allis-Chalmers Manufacturing Company. The "Texrope" grommet v-belt is said to be the only belt made without a splice. According to the bulletin, it is cooler running, is shock absorbent, has one-tenth the shrinkage and one-third the stretch of other belts.

Circle letter (AZ) on reply card.

(BA) REGULATING VALVES

The D'Este Division of Kaye and MacDonald, Inc., announces the issuing of a new bulletin, No. 535. This bulletin covers the company's line of steam pressure regulating valves, introducing three new items, Type F, FR, and PR. Complete sizing tables are included as well as an interesting section on choosing a regulating valve.

Circle letter (BA) on reply card.

(BB) STEAM TRAP

A new two-page Bulletin No. 351 features a new Type D thermostatic bellows steam trap recently added to the W. H. Nicholson and Company line. This trap is smaller in size, capacity and price than other types made by this company, and is intended to meet the requirement of many applications for a smaller trap. It embodies several improved design features, including large hexagon shanks.

Circle letter (BB) on reply card.

(BC) THERMAL INSULATION

Ultrafine, the new thermal and acoustical insulation made of extremely fine, blown glass fibers and the newest addition to the "family" of insulations manufactured by the Gustin-Bacon Manufacturing Company is the subject of a four-page folder that lists all pertinent information on the new product. Complete with pictorial illustrations of the product in use, and with tables demonstrating Ultrafine's thermal and acoustical efficiency, the brochure treats in detail physical properties, principal uses, etc.

Circle letter (BC) on reply card.

(BD) STEEL TUBING

"Patco" steel tubing and cold finished rods and bars are described in Bulletin No. 10 just published by Pacific Tube Company. The six-page folder gives standard manufacturing tolerances on outside diameter, inside diameter, wall thickness, and commercial lengths for various sizes of tubing; also, size ranges for standard production of cold drawn carbon steel and alloy steel tubing, electric resistance welded steel tubing, stainless welded and drawn tubing, etc.

Circle letter (BD) on reply card.

(BE) PAINTS, PRIMER

The U. S. Stoneware Company has just released the enclosed 16-page Bulletin No. 730, on Tygon paint. This bulletin not only gives a full description of Tygon paint, but also incorporates information on Tygorust, the new "no-prep" vinyl primer, which has created much interest in the field of corrosion-resistant coatings. Bulletin No. 730 tells where and where not—how, and how not to use Tygon paint and Tygorust primer.

Circle letter (BE) on reply card.

(BF) VALVES

The Annin Company has published a new bulletin on Annin valves, containing 19 pages of data, diagrams, and illustrations. The 2-color bulletin gives detailed information on various kinds of Annin valves. Basically, all Annin valves are single seat, the body consisting of separable halves that are bolted together at the replaceable valve seat ring. Standard series valves bodies are rated from 2500 psi in the ¾-in. size to 1000 psi in the 4-in. Effective standard temperature range is from —100 deg to the 450 F using Teflon pacing.

Circle letter (BF) on reply card.

(BG) AUTOMOBILE RESEARCH

Fisher Scientific Company has announced that Volume 22, No. 2 of "The Laboratory" is now available. The 9-page, illustrated lead article is a report on "the countless laboratory contributions to the car of today — and tomorrow." Scientists of five major automobile companies contributed to this survey of Detroit's $100,000,000-a-year research program. New instruments announced in this issue include two compact assemblies that convert pH-meters into titrators for obtaining precision curves.

Circle letter (BG) on reply card.

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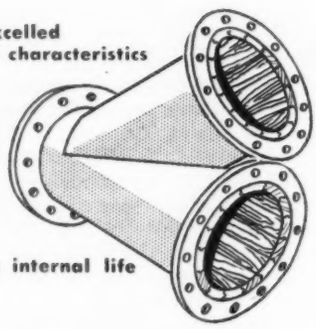

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Trade Personals

(BH) COMPRESSORS

A new, comprehensive M-line compressor bulletin has just been released for distribution by The Cooper-Bessemer Corporation. This 44-page engineering type catalog provides basic application data with design specifications on Cooper-Bessemer's complete line of reciprocating compressors from 100 to 5000 hp. Compressors are powered by electric motors or internal combustion engines.

Circle letter (BH) on reply card.

(BI) PLASTIC PIPE

The plastic products division of Triangle Conduit and Cable Company, Inc., announces the publication of a 16-page brochure on plastic pipe. It contains all pertinent information on Triangle's four types: Flexible, semi-rigid, rigid high impact, and rigid polyvinyl chloride pipe. Detailed tables give chemical and physical characteristics of each type.

Circle letter (BI) on reply card.

(BJ) WELDING EQUIPMENT

The Modern Engineering Company, manufacturers of "MECO" welding equipment, has announced the completion of their new catalog, No. 150. This

catalog contains every type of welding equipment necessary for all oxy-acetylene welding and cutting operations. The text, plus over 150 illustrations, provide a complete and comprehensive guide for every welder. Each item of equipment is explained in detail with specific recommendations for its use.

Circle letter (BJ) on reply card.

(BK) PURIFIERS

New literature on V. D. Anderson Company's line type Hi-eF purifiers is announced. Well illustrated, this folder tells how these mechanical separators save money for virtually every type of plant by cleaning up objectionable entrainment. Installation photos illustrate equipment arrangement and blueprint drawing shows piping layouts. Drawing, selection tables, dimensions, capacities, and prices are included.

Circle letter (BK) on reply card.

(BL) TURBINE PUMPS

"Vertical Pumps for Volatile Fluids" is a new bulletin describing the advantages of Johnston Pump Company's vertical turbine pumps for handling gasoline, diesel fuel, crude oil, L-P gases, ammonia and other volatile liquids. It is profusely illustrated with cross-section drawings.

Circle letter (BL) on reply card.

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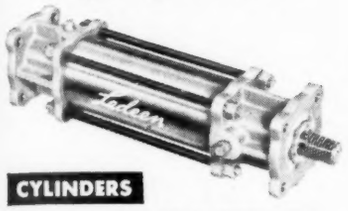

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For air, oil, water, gas or steam operation—in standard and special diameters and stroke lengths.
Write for Bulletin 500

VALVES
For operating air and hydraulic cylinders and motors, single and double acting. Hand, foot, power and solenoid operated.
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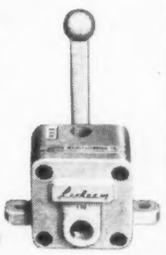

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High pressure oil, from plant air supply. For clamping, drawing, forming, testing and other operations requiring long high pressure cycles without vibration or overheating. Ready for connection to plant air and hydraulic lines.
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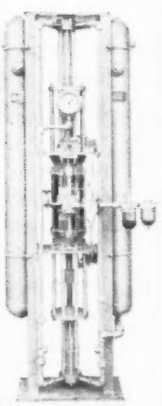

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(BM) ELECTRIC PLANT

A new, 180-cycle, gasoline engine-driven electric plant, designed to operate high frequency electrical work tools, has been announced by D. W. Onan and Sons Inc. At unity power factor it provides 5000-w of a-c, 230-v, 180-cycle, 3-phase power or 3000 w, 230-v, 180-cycle a-c plus 2000 w, 115-v d-c. Model 5CK-185M provides independent power for 180-cycle electric tools where no standard power is available for conversion.

Circle letter (BM) on reply card.

(BN) ETHYLBENZENE

A booklet that brings together chemical, physical, and reaction data on ethylbenzene, a highly reactive aromatic hydrocarbon, has been published by Monsanto Chemical Company's Texas division. A water white liquid that boils at 136 C, ethylbenzene's chemical reactions include oxidation, nitration, sulfonation, hydrogenation, dehydrogenation, halogenation, alkylation, and acylation.

Circle letter (BN) on reply card.

(BO) FLEXIBLE TUBING

Flexible tubing for ventilation, fume and dust removal, and materials handling is described in a new 8-page bulletin available from Flexible Tubing Corporation. Catalog C2-4 gives detailed information on Spiratube A and Spiratube R, two types of highly flexible light-weight tubing made from continuous helical coils of spring wire wound with overlapping plies of specially-treated multi-coated fabric.

Circle letter (BO) on reply card.

(BP) AUTOMATIC VALVES

A new 8-page bulletin describing the features of Golden Anderson's cushioned automatic water and steam valves is available from Golden Anderson Valve Specialty Company. Featured in this catalog are float, altitude, check, solenoid-operated, reducing, relief, and non-return valves.

Circle letter (BP) on reply card.

(BQ) VERTICAL PUMP

Construction features of Allis-Chalmers small vertical pumps for sidewall or submerged mounting are described in a new eight-page bulletin released by the company. Units covered are available in capacities to 250 gal per minute at heads to 125 ft for coolant circulating, air conditioning, etc. Helpful curves and tables are included in the bulletin.

Circle letter (BQ) on reply card.

(BR) PROTECTIVE COATING

Flexrock Company has announced a new type coating, the Flexcoat maintenance coating, developed to meet the needs of industry for a coating that would give protection against corrosion caused by atmospheric conditions, vapors, fumes, spillage, and splash of chemicals which destroy expensive machinery and equipment. Flexcoat meets all these requirements, the manufacturer claims.

Circle letter (BR) on reply card.

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National TREATERS ELIMINATE BOILERS IN CANADIAN TANK BATTERY INSTALLATIONS

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SITUATION: When National Tank first entered Canada in 1948, boilers were a "must" in all tank battery installations to maintain pour point in temperatures up to 60° below zero.

PROBLEM: Boiler installations were expensive. Water supplies were critical and because of extreme cold, continuous operation was required or careful draining of steam and water lines was necessary if lease was shut down for only a short length of time. To begin operations again meant costly refilling of water systems. Steam coils in storage tanks caused a large amount of evaporation of oil in tanks . . . as much as 3" in one 1000 Bbl. tank.

NATIONAL'S SOLUTION: Treater installation costs are about the same as boiler costs. National engineers helped their customers re-design piping hook-ups and circulating lines. They suggested putting the oil into the bottom of the tanks. In 1951, 98% of tank batteries were built with treater installations instead of boilers. Tanks have bottom fills. Pour point is maintained by circulating oil from tanks through treaters. Piping is arranged to allow hot oil to circulate through manifold, headers and separator. Treaters can be shut down for several days in extreme cold without draining water or for longer periods by draining water from treater only.

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